VOLUME LXI NUMBER 8 WHOLE 541

SCHOOL SCIENCE AND MATHEMATICS

NOVEMBER 1961

School Science and Mathematics

A Journal for All Science and Mathematics Teachers

All matter for publication, including books for review, should be addressed to the editor. Payments and all matter relating to subscriptions, change of address, etc. should be sent to the business manager.

Second-class postage paid at Menasha, Wisconsin and at additional mailing offices. Published Monthly except July, August and September at Curtis Reed Plaza, Menasha, Wis. PRICE: Six dollars a year; foreign countries $6.50; current single copies 75 cents.

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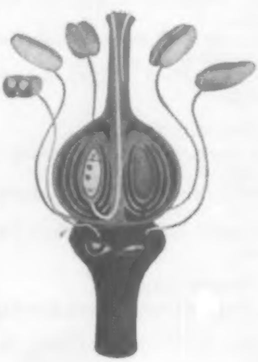

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SCHOOL SCIENCE AND MATHEMATICS

VOL. LXI | NOVEMBER, 1961 | WHOLE NO. 541

A Study of the Use of Special Teachers in Science and Mathematics in Grades 5 and 6*

E. Glenadine Gibb and Dorothy M. Matala[1]

Iowa State Teachers College, Cedar Falls, Iowa

This *preliminary report* on the use of special teachers in science and in mathematics in Grades 5 and 6 is based on analyses of the data collected during the first year of the study.[2] The report of the study will not be made until after the second year of the study, to be completed in June, 1961. Therefore, any results reported here may be quite different after the two-year study.

HYPOTHESES TESTED

Using gain scores determined by the pre- and post-instructional testing program for the academic year, 1959–1960, comparisons have been made between two groups, one group taught mathematics and science by special teachers, and the other group taught mathematics and science by teachers in self-contained classrooms. These comparisons have enabled us to test the following null hypotheses:

1. There is no difference in insights and understandings gained in science and in mathematics by boys and girls in either grade 5 or grade 6, regardless of the classroom organization, that is, special teachers or teachers in self-contained classrooms.

---

* This is a *preliminary* report of a study in progress.

[1] Dr. Gibb, director of the evaluation of this study, and her associate, Dr. Matala, are members of the Department of Mathematics and the Department of Science, respectively, at Iowa State Teachers College.

[2] For a description and background of the study, see report on "Study of the Use of Special Teachers of Science and Mathematics in Grades 5 and 6," Science Teaching Improvement Program, American Association for the Advancement of Science, Washington, D. C.

2. There is no difference in insights and understandings gained by boys and girls in either grade 5 or grade 6 regardless of the school system. It will be recalled that these centers were selected to represent different kinds of systems—from rural districts to metropolitan areas.

3. There is no difference in change of interest in science, mathematics and social science for children in either grade 5 or grade 6, regardless of the kind of teacher or the school system with which they are identified.

Also, at the close of the first year, a sample selected at random from each classroom making up the population for the study and teachers who took part in the study—special teachers, teachers of self-contained classrooms, and homeroom teachers, were interviewed. However analyses of these interviews sill be included in the final report.

TENTATIVE ANSWERS

Using the technique of the analysis of variance to compare differences in methods, systems, and interactions of method and system, we are able to give some tentative answers to the following questions asked in the earlier report. It is quite possible that after more data have been collected and over a longer period of time, these questions may be answered quite differently.

Regarding Science

1. *Can science be as effectively taught by teachers in self-contained classrooms as by special teachers?*

For fifth grade our present answer is yes. For sixth grade our answer is no. The two methods groups in sixth grade were different at the 5% level of significance, in favor of more effective teaching being done by the special teachers.

2. *Regardless of which method is used, is the science learning (as measured by the instrument used), similar for each system? Is one method of classroom organization of teachers better for one system and another organization better for another?*

Evidence is such that we would have no reason to say there was any difference. Therefore, we have no reason to give a "no" in answer to either question.

Regarding Mathematics

1. *Can mathematics be as effectively taught by teachers of self-contained classes as by special teachers?*

Our present answer to this question is that we have no evidence upon which to base a prediction that one is more effective than the other for either Grade 5 or Grade 6.

2. *Regardless of which method is used, is the mathematics learning (as measured by the instrument used), similar for each system? Is one method of classroom organization of teachers better for one system and another organization better for another?*

Again, from our present data we have no bases for predicting that one method is better than the other. So, again, we have no reason to give a "no" in answer to either of these questions.

Regarding Social Science

1. ***With the possibility of emphasis on science and mathematics, do other areas suffer?***

To answer this question, we examined the area of social studies. Again, as with the mathematics, we found no difference between the two methods groups, those taught all subjects by one teacher and those who had special teachers for mathematics and for science.

Change of Interest

In *science*, for Grade 5 there was no change of interest that can be attributed to classroom organization. However, the changes between systems were significantly different. Within some systems the change towards more interest in science was made by those children having special teachers. Still, for other systems a similar change was made by those children who had as their science teachers, teachers in self-contained classrooms. One might say that perhaps some systems already had more interest in science. Consequently, one would not expect much change. It is evident that the teacher is a very important factor in change of interest—whether he is a special teacher or a teacher in a self-contained classroom does not always make the difference. In *Grade 6* there was a highly significant difference between the two methods in favor of more positive interest on the part of those children having special teachers. However, this difference must be attributed to the fact that those children with special teachers merely lost less of their interest than those taught by teachers in self-contained classrooms. This loss of interest cannot be accounted for by any evidence presently available. There was also a significant difference between school systems regardless of the kind of teachers.

In *mathematics*, the picture is different. Children in *Grade 5*, taught by special teachers became significantly more interested in mathematics than those taught mathematics by teachers in self-contained classes. This result was true for all systems participating in the study. However, for *Grade 6* neither positive nor negative change of interest could be attributed to the kind of teacher. There was significant difference between systems. Again, one might say that interest already existed within some systems which did not exist in other systems. Or, the programs are such that they may stimulate more interest in some systems than in other systems. Support for these "hunches" is not being pursued until after the second year of the

study. However, data has been collected so that these can be exploited if such seems advisable in giving us guideposts for making decisions.

In *social science*, there was no significant difference between methods groups or between systems for either grade. Thus, we have no reason to believe that this kind of organization detracted from interest in other areas. Although not significantly different, there were positive changes in interest by those children in 5th Grade having special teachers in science and mathematics and loss of interest by those taught by teachers in self-contained classrooms. In Grade 6, there was a loss of interest for both groups but less for the children taught science and mathematics by special teachers. Yet, as stated above, this difference was not significant.

A Concluding Remark

Again, may we keep in mind that this is only a ***preliminary report.*** Will the picture be similar after children have experienced either having two years of having the same special teachers in mathematics and in science or two years having two different teachers teaching mathematics and science but also teaching them in other areas as well? At this time, we cannot say. In the meantime, we conclude that this report ***does not support either type of organization as being superior for all school systems.***

Darwin and Fabre: A Sidelight

Arthur Porges
236 Viejo St., Laguna Beach, California

Charles Darwin, after reading his earliest publications on insects, called Jean Henri Fabre "the inimitable observer." The English titan's admiration was undoubtedly sincere, even though we find him troubled, as a theorist, by the obscure Frenchman's objections to Natural Selection as a major factor in the marvelous adaptations of insects. It was quite typical of Darwin to consider seriously every reasonable challenge to his doctrine of organic evolution through preservation of minor changes beneficial to a species. In the *Origin of Species* he raised more obstacles to acceptance of the book's underlying thesis than all his most vocal critics could ever have found for themselves. Many of these he managed to explain away by ingenious, and usually plausible, reasoning. In some cases the evidence he needed was not available until long after his death; yet Darwin inferred that it must exist, and time has proved him right.

Fabre, who outlived the English master by twenty-seven years—he died at ninety-two—corresponded with him only briefly, during the last two years of his life, from 1880 until 1882. In his later works, however, he often refers to Darwin, and, so to speak, attempts to refute the dead giant, for Fabre never lost his hostility towards the theory of evolution.

The French naturalist, one of the first men to study insect behavior diligently and with incomparable patience outside the laboratory, apparently subscribed to Newton's philosophy, and dislike to frame hypotheses, at least, comprehensive ones of the sort that immortalized Darwin. Abandoning the purely anatomical and taxonomic aspects of entomology so favored in his day, he preferred to study insects in the field, developing and proving many fascinating theories about their habits, but always within the setting of something unknowable and forever beyond explanation, except by Divine Law. In short, "instinct," God-given to most living things, and a trait that could never have arisen through so puerile a mechanism as Natural Selection. He was devoutly religious, and to him the far-ranging implications of evolution, which eliminated God the Creator from all but the first link of the chain of being, were anathema.

Fabre always professed great respect for Darwin's character and integrity, ostensibly approving the man, while like Saint Augustine, despising his beliefs. He seems to have regarded him as a philosopher of doubtful ability, given to easy generalizations unchecked by rigorous work in the field and laboratory. Further, he must have

thought Darwin offensively materialistic, too arrogant to save a place in his cosmos for the sort of Deity vital to Fabre's universe.

Not that the French schoolmaster, fully as gentle in speech and print as Darwin himself, ever said all this in so many words. On the contrary, he often refers to the older man in such terms as "illustrious master," and speaks of his biological researches with almost exaggerated respect. But, on reading between the lines, one is bound to suspect much implied irony; and the constant use, in regard to himself, of such words as "humble" and "obscure" seems somewhat overdone. One might guess at a Lucifer's pride beneath the mock humility.

It should not be thought, however, that the clash—or rather, lack of rapport, since the two men never really quarreled—was purely one of basic philsophy of science: the meticulous student of detail in the field rejecting the armchair speculations of a theorist. Fabre was sufficiently intelligent and well read in biology to accredit Darwin as a highly qualified naturalist. He must have been aware that the Englishman's early researches on barnacles, not to mention the "Beagle" reports, were equal, in terms of precise, minute observation, to anything ever done in science. If Darwin could not match Fabre's work stylistically, that was not because he wrote badly; since he usually composed with vigor and clarity; but rather because the younger man was a superb literary craftsman, whose essays are among the best ever produced by a naturalist. There are few enough popularizers today, fifty years later, who can make a paragraph about a scarab beetle not only lucid and exciting, but as artfully constructed as a classical symphony.

Of course, the two men did differ, more in their beliefs, it would seem, than in their temperaments, which were surprisingly similar. Both were gentle, modest, family men, greatly beloved by their families and friends. Darwin was far from being as materialistic as Fabre believed; and the Frenchman could speculate as daringly as the Englishman, provided, as always, that the frame of orthodox religion wasn't displaced in the process.

Although there might have been a number of points at issue between them, in terms of biology, the real one was the tricky problem of insect behavior, and that of the hunting wasps in particular.

Fabre's brilliant studies, from 1852 to about 1858, in Avignon and Carpentras, had established beyond any doubt that certain wasps are capable of extremely delicate surgery on the insects—usually a single species—which form their prey. By artfully stinging key nerve centers of its victim, the female predator is able to provide its young with living but paralyzed food that will remain fresh for days. If the immobilized insect should die too soon, the wasp's grubs are

also doomed, since they cannot live on carrion. But if the surgery is inadequate, so that the victim can writhe or turn, the young may be crushed. Further, the grubs must not eat in a random manner, but avoid the vital organs as long as possible, lest their prey be killed too early in the game. It follows that any break in this intricate chain: precise surgery, circumspect eating—and the young cannot reach maturity.

It seemed quite obvious to Fabre that so amazing and restricted a behavior pattern could not have arisen from any sort of continuous variation in the habits of successive generations of wasps. He argued that the very first nerve-operation of the female had to be perfect, or its grubs would surely die. And even if the victim were properly paralyzed on the initial attempt, it was still essential that the young know exactly how to consume their fresh food without killing it prematurely. That so complicated a sequence could have arisen by any natural, mechanistic process seemed completely unacceptable to the Frenchman. He preferred to regard the matter as one of instinct, a quality mysteriously present in each new-born insect through the omniscience of a Supreme Being.

Darwin saw the validity of this objection, and manfully grappled with it. Like one of Fabre's ants, he was not the sort to avoid any obstacle in his path. Instead of by-passing it, he tackled the problem head on, postulating certain intermediate forms of the wasp species, of which no fossilized types had been found. But in 1880, when Darwin was confronting the difficulty anew, the data needed to resolve it were unavailable. Both men, in fact, were reasoning from the premise of continuous change. The Mutation Theory of De Vries, and the work of Mendel on the mechanism of heredity, lay many years in the future. If Darwin had known that insect evolution could proceed in larger steps than the tiny variations he observed, in his field studies, among members of a given species, the puzzle of instinct might have been put in its true perspective. Without that knowledge, the controversy suggests two blindfooded men, both very agile, engaged in a fencing match. Darwin, as it happened, turned out to be right without knowing why; and Fabre was wrong in spite of the most impeccable reasoning. Today few biologists would question the conclusion that Natural Selection is a major factor in the evolution of instinctive behavior in insects. Not that all the problems have been resolved; there are plenty left.

In a letter to J. G. Romanes, written in 1881, Darwin said:

> I do not know whether you will discusss in your book on the mind of animals any more of the complex and wonderful instincts. It is unsatisfactory work, as there can be no fossilized instincts, and the sole guide is their state in other members of the same order, and mere ***probability***.

But if you do discuss any (and it will perhaps be expected of you), I should think that you could not select a better case than that of the sand wasps which paralyze their prey as described by Fabre in his wonderful paper in the "Annales des Sciences," and since amplified in his admirable "Souvenirs."

Here is Darwin, one of the most fair-minded scientists who ever lived, urging into print material most readily employed by opponents of his Theory of Natural Selection!

And Fabre's comment, which seems to lack charity, especially since Darwin had just died:

I think you, O illustrious master, for your eulogistic expressions, proving the keen interest which you took in my studies of instinct, no ungrateful task—far from it—when we tackle it as it should be tackled: from the front, with the aid of facts, and not from the flank, with the aid of arguments. . . .

Fabre is definitely on the side of the angels in this statement. With Bacon and Galileo he demands the experimentum crucis, the posing of a vital question to Nature, as the only proper means of settling a scientific difference. Not for him the grand, vague Aristotelian flights of the imagination, disdainful of mere facts. But how did his attitude differ when Darwin, a few months before his death, asked him to collaborate in a research problem about instinct? Surely Fabre must have rejoiced that the "master" was at last willing to abandon argument for experimentation. Unfortunately, the tone of his reply doesn't support such an inference. Once more the matter at issue is insect behavior, apparently inborn: the homing ability of the mason-wasp.

Some years earlier, Darwin had intended to explore the problem first by means of pigeons. He proposed to place them in closed boxes, which would then be carried off some distiance, and twirled in a random way to impair, if possible, the birds' knack for returning to their loft from miles away. Unable at the time to carry out this plan, he urged Fabre to attempt the same experiment with mason-bees. The Frenchman, full of doubt, did so. He reported:

He [Darwin] expected a success and was much surprised at the failure. Had he had time to experiment with his pigeons, they would have behaved just like my bees; the preliminary twirling would not have affected them.

Then, even more skeptical, he considers an alternative proposal of Darwin's. The Englishman had written, in a postscript to his letter about the pigeons:

If this plan [the spinning in a box] failed, I had intended placing the pigeons within an induction coil, so as to disturb any magnetic or dia-magnetic sensibility, which it seems just possible that they may possess.

Does this assumption appear too fantastic? Fabre evidently thought so. Commenting on Darwin's suggestion, he becomes almost bitter:

To treat an insect as you would a magnetic needle and to subject it to the current from an induction coil in order to disturb its magnetism or diamagnetism

appeared to me, I must confess, a curious notion, worthy of an imagination in the last ditch. I have but little confidence in our physics, when they pretend to explain life; nevertheless, my respect for the great man would have made me resort to induction coils, if I had possessed the necessary apparatus. But my village boasts no scientific resources: if I want an electric spark, I am reduced to rubbing a sheet of paper on my knees. My physics cupboard contains a magnet; and that is about all. . . .

Here, to digress a moment, is another small irony relating to these men. Darwin, born to a life of ease, with no financial problems, voluntarily subjected himself to the ordeal of the "Beagle," knowing that he was a hopelessly bad sailor, doomed to endless bouts of seasickness. Able to live at home, in comfort, he went thousands of miles, suffering many hardships, and, in all probability, acquiring some tropical disease that made him a permanent invalid.

Fabre, who asked nothing more than a few square feet of land on which to study his beloved insects without being harassed by pop-eyed yokels, had to battle oppressive poverty all his life. Ever the underpaid schoolteacher, he had no equipment to match his genius as scientist. It was not until his retirement, as an old man, that he finally acquired his bit of land—a weedy jungle-patch of soil.

But to return to instinct, Fabre's poverty was no bar to Darwin's imagination. He suggested that a thin needle, magnetized and broken into tiny pieces, would supply enough small magnets for the experiment. He wrote:

I believe that such a little magnet, from its close proximity to the nervous system of the insect, would affect it more than would the terrestrial currents.

Fabre was not impressed with this ingenious proposal. He observed, in an ironical mood:

With a tiny magnet fastened on its thorax, parallel with the nervous system and more powerful than the terrestrial magnetism by reason of its comparative nearness, the insect will lose its bearings. Naturally, in setting down these lines, I take shelter behind the mighty reputation of the learned begetter of the idea. It would not be accepted as serious coming from a humble person like myself. Obscurity cannot afford these audacious theories.

Nevertheless, still deferring to the "master," he did try the experiment. Using a bit of adhesive tape, he fastened the tiny needle magnet to a mason-bee's thorax. The insect indignantly refused to co-operate with him on behalf of Darwin:

The moment she is free, the Bee drops to the ground and rolls about like a mad thing, on the floor of the room. She resumes her flight, flops down again, turns over on her side, on her back, buzzes noisily, flings herself about desperately and ends by darting through the window in headlong flight.

For a moment Fabre may have been shaken. It might have occurred to him that Darwin was right, after all. But he was far too good a scientist not to design a control experiment. When a bit of

straw, quite non-magnetic, was fastened to another bee, the insect behaved the same way as the first one did.

Fabre reported this in his customary vein when dealing with the Philosopher of Down:

> To look to her for normal actions so long as she carries an apparatus, magnetized or not, upon her back is the same as expecting to study the natural habits of a Dog after tying a kettle to his tail.
>
> The experiment with the magnet is impracticable. What would it tell us if the insect consented to it? In my opinion, it would tell us nothing. In the matter of the homing instinct, a magnet would have no more influence than a bit of straw.

Darwin died in 1882, before these results were known to him. In fact, he saw only the first of Fabre's magnificent volumes making up the "Souvenirs."

One wonders what Fabre would say to modern researches on the honeybee, which have shown that it finds its way from hive to flowers and back by means of polarized light. Light is, of course, an electromagnetic phenomenon, and may also explain the migration of birds. It is well known that pigeons cannot home in the dark, or when the sky is heavily overcast.

There are still those, like Dr. Agatha Magnus, who cling to the magnetic field theory of migration. But her experiments were not capable of verification by other scientists, and are not generally accepted as valid.

The mystery still remains; but the fact that there are still naturalists trying to verify Darwin's bold speculations would give Fabre something to ponder!

Chief Sources

The Complete Works of Fabre, Dodd-Mead Edition.
The Life of Jean Henri Fabre—Augustin Fabre.
The Life and Letters of Charles Darwin—Francis Darwin.
Origin of Species—Charles Darwin.
The Living Thoughts of Darwin—Julian Huxley.
The Meaning of Evolution—George G. Simpson.

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Teaching Machines

An Annotated Bibliography

Margaret F. Willerding

San Diego State College, San Diego, Calif.

The field of teaching machines or auto-instructional devices began with Pressey in 1926. Interest and literature have been sparse until 1958, but since then papers have been appearing at an exponential rate.

The author uses the term teaching machine in this article to be defined as a device which conveys information in unit form, demands a response, and then informs the student of the correctness of his response.

The "program," that is, the material in unitized form used by the machine, can also be presented without a mechanical device and as such is included in this study. It is the essence of the technique without which the device itself would be useless. In other words, the teaching machine is only as good as its program.

Two recent works, Fry (1960) and Lumsdaine (1960) deserve particular note. Both contain excellent extensive bibliographies as well as other material in the field of auto-instruction. The latter contains almost all of the references contained in Fry's book, many reprinted in their original entirety.

Because Lumsdaine has collected every paper worthy of note together in one book, no attempt is made here to include the Armed Forces publications or unpublished papers. Some of the work in this field has been done under the sponsorship of the Armed Forces. This material if unpublished, remains relatively inaccessable, though both Fry and Lumsdaine refer to these works.

Although many teachers have heard the term "teaching machine," most of them are vague as to just what the term means with reference to teaching elementary students. The author has assembled this bibliography to acquaint teachers with the literature which is available in this new field of auto-instruction.

"AFT Vice-President in Dim View of Teaching Machines," *The American Teacher*, 7: 8, September, 1960.

While proponents of teaching machines act from idealistic motivations, boards of education who see them as "gimmicks" to reduce taxes by jamming classrooms and "increasing production" are doing education a disservice observed Edward A. Irwin.

Ahrendt, M. H. "Newer Trends in Teaching Mathematics," *School and Society*, 88: 329–30, September 24, 1960.

A report of the 38th meeting of the National Council of Mathematics, Buffalo, New York. Contains a statement that the monotonous processes in mathematics should be taught by machines to clear the way for more creative activities.

Allen, William H. "Teaching Machines in the Limelight," *Audiovisual Instruction*, 5: 168–69, June, 1960.

The DAVI Convention, June, 1960, heard leaders in the field of teaching machines discuss the different approaches and techniques.

Amsel, A. "Error Responses and Reinforcement Schedules in Self-Instructional Devices." *Teaching Machines and Programmed Learning: a Source Book* (Edited by A. A. Lumsdaine and Robert Glaser). Washington, D. C.: National Education Association of the United States, 1960. p. 506–16.

This article is a review of Skinner's work on error responses and reinforcement schedules in self-instructional devices. It discusses some of the premises set forth by Skinner an others.

Angell, George W. "Effect of Immediate Knowledge of Quiz Results on Final Examination Scores in Freshman Chemistry," *Journal of Educational Research*, 42: 391–94, January, 1949.

Punchboards are evaluated using test groups and concluded to be effective because of the immediate knowledge of results factor.

———, and Maurice E. Troyer. "A New Self-Scoring Device for Improving Instruction," *School and Society*, 67: 84–85, January 31, 1948.

The use of a punchboard accompanied by multiple-choice answer sheets is described. The immediate knowledge of success or failure of a response is cited as being a valuable asset of this technique.

Babcock, Chester D. "Teacher, T. V., and Teaching Machines," *National Education Association Journal*, 49: 30–31, May, 1960.

The role of the teacher will change through technology but it confuses the issues to compare teaching machines with teachers. Machines are only teaching tools.

Barlow, John A. "Project Tutor," *Psychological Reports*, 6: 15–20, February, 1960.

Mr. Barlow asks searching questions aimed at improving teaching through the use of the "self-instruction device or semi-automatic tutor." He points out strengths and weaknesses. Though it is an infant field, it is time to put the toys aside.

———. "Trends In the Use of Learning Machines," (In National Conference on Higher Education. Current issued in Higher Education, 1960. Pp. 255–58.)

Beck, Jacob. "On Some Methods of Programming," *Automatic Teaching: The State of the Art*. Eugene Galanter (ed.) New York: John Wiley and Sons, 1959. Pp. 55–62.

An examination of how a machine can best convey information, elicit the correct response and in fact teach, is presented.

Blumenthal, Joseph C. *English 2600*. New York: Harcourt, Brace and Company, 1960. 439 pp.

This is a scrambled book which teaches the basic use of English by the use of ideas presented in small increments requiring student response and providing immediate knowledge of results.

Blyth, John W. "Teaching Machines and Human Beings," *Educational Record*, 41: 116–25, April, 1960.

The author, working with John Jacobson, experimented on teaching logic in college in an extensive program using microfilmed material. A good analysis of advantages and a discussion of programming is presented.

Boehm, George A. W. "Can People Be Taught Like Pigeons?" *Fortune*, 62: 176–79, October, 1960.

This is an excellent review of the field: its problems, its leaders, machines, philosophies and principles of programming.

Boroff, David. "The Three R's and Pushbuttons," *The New York Times Magazine*, September 25, 1960. p. 36.

The conflict in the classroom about the role of the teacher under the conditions brought about by teaching machines is explored.

Boutwell, W. D. "What's Happening in Education?" *National Parent Teacher*, 54: 11–12, June, 1960.

Briggs, Leslie J. "Applied Research Problems," Abstracts from Symposium on Automation Teaching, Western Psychological Association Annual Meeting, San Diego, April, 1959*

Briggs outlines three stages necessary for training: Identification of learning, programming, and development of hardware.

———. "Teaching Machines, Education and Job Skills," *Psychological Reports*, 5: 210, June 1959.

Prospects for the future are explored. Reinforcement and adaptability to individual differences are the fortes of teaching machines.

———. "Teaching Machines for Training of Military Personnel in Maintenance of Electronic Equipment," *Automatic Teaching: The State of the Art*. Eugene Galanter (ed.) New York: John Wiley and Sons, 1959. Pp. 131–45.

Two types of teaching machines are described, one for learning verbal facts, another for learning complex procedural techniques. Future areas requiring research are pinpointed.

———. "The Development and Appraisal of Special Procedures for Superior Students and an Analysis of the Effect of 'Knowledge of Results'," *Abstracts of Doctoral Dissertations*, Number 58, The Ohio State University Press, 1949.*

This reports on an accelerated course using Pressey punchboards to reinforce learning in which students achieve to a greater degree than the central group, inspite of fewer classes.

———. "Two Self-Instructional Devices," *Psychological Reports*, 4: 671–76, December, 1958.

This article describes the Subject Matter Trainer, a versatile machine which can teach, test and pace multiple items.

Carpenter, Finley. "How Will Automated Teaching Affect Education?" *The University of Michigan School of Education Bulletin*, October 1959.*

This is a consideration of the principles underlying the use of teaching machines.

Carr, W. J. "Self-Instructional Devices: A Review of Current Concepts." *Teaching Machines and Programmed Learning: a Source Book* (Edited by A. A. Lumsdaine and Robert Glaser). Washington, D. C.: National Education Association of the United States, 1960. p. 540–62.

This article is a functional analysis of self-instructional devices. It reviews current concepts to date of writing.

Casmir, Fred L. "The Human Teacher is Still Best," *CTA Journal*, 56: 41–44, September, 1960.

An argument is presented against the use of machines because they cannot adjust to emotional problems, psychological difficulties, or semantic problems. They are amoral and regiment the student.

Corrigan, Robert E. "A Solution to Some Pressing Problems in Education," *CTA Journal*, 56: 11–12, September, 1960.

Predetermined quality, continuous student activity, immediate correction of errors, and pacing consistent with capacity are cited as the benefits of automated teaching.

———. "Automated Teaching Methods," *Automated Teaching Bulletin*, September, 1959.*

Corrigan presents an introductory article about teaching machines.

Coulson, John E. "An Experimental Teaching Machine for Research At San Diego College," *Technical Memorandum*, System Development Corporation, Santa Monica, California, October, 1959.*

Branching is necessary for a teaching machine.

———. "Programming for Individual Differences," Abstract of paper presented in a Symposium on Automated Teaching, Western Psychological Association, San Diego, April, 1959.*

The effective teaching machine must react to the students response and alter its program accordingly.

———, and Harry F. Silverman. "Effects of Three Variables in a Teaching Machine," *Journal of Educational Psychology*, 51: 135–43, June, 1960.

Multiple choice versus constructed response, small steps versus large steps and non-branching versus branching were studied and conclusions reached indicate the first mentioned in each case has the greater merit.

———. "Proposal for Extension of Automated Teaching Projects." Field Note, System Development Corporation, Santa Monica, California, July, 1959.*

The use of a computer to develop a teaching machine is reported by Coulson.

Cross, K. Patricia, and Eugene L. Gaier. "Techniques in Problem Solving as a Predictor of Educational Achievement," *Journal of Educational Psychology*, 46: 193–206, April, 1955.

A test instrument was used in which tabed paper covers could be removed so that the amount of information available to different subjects differed according to their needs.

Crowder, Norman A. *An Automatic Tutoring Book on Number System.* Vol. I, Timonium, Maryland: Hoover Electronics Co., 1958.*

This is a scrambled book, which achieves "intrinsic programming." That is, alternate branching loops are available, depending on the students response.

———. "Automatic Tutoring by Means of Intrinsic Programming," *Automatic Teaching: The State of the Art.* Eugene Galanter. (ed.) New York: John Wiley & Sons, 1959.

Mr. Crowder gives a detailed report about the differences between his approach and Skinners. The scrambled book is explained with examples.

———. "Automatic Tutoring Using Intrinsic Programming," *Tutorings: The Newsletter of Automated Teaching*, Western Design, Goleta, California, 1960.

The "Auto Tutor" and "Tutor Text" teaching machines, principles of programming and machine design are effectively considered.

———. "Intrinsically Programmed Teaching Devices," An Invitational Conference on Testing Problems. Proceedings, 1959, Pp. 40–52.

———. *The Arithmetic of Computers.* Galeta, California: Western Design, 1960.

This is a Tutor Text, Western Designs name for a programmed textbook. The student proceeds among a branched course depending on his responses to questions on each page.

Darby, Charles L. "An Annotated Bibliography on the Automation of Instruction," Draft of research memorandum, Joseph C. Hammock, Director of Research, U. S. Army Air Defense, Human Research Unit, Fort Bliss, Texas, April, 1959.*

An annotated bibliography on teaching machines and general theory which is effectively reviewed by Fry.

Day, Jesse H. "Teaching Machines," *Journal Chemical Education*, 36: 591–95, December, 1959.

The importance of programming is emphasized in a lucid report covering typical machines, experiments and a discussion of the difficulties inherent in a new field.

Edwards, Ward. "Skinners Teaching Machines," Unpublished draft, Air Force personnel and Training Research Center, Tawny Air Force Base, Colorado, May, 1956.*

Skinners Machines, techniques and principles are reported at a time when he was far out in front of the field in his thinking.

Elgin, Lewis D. "The Construction of Frames of an Automated Teaching Program," Collegiate School Automated Teaching Project, New York, November, 1959.*

Elgin offers an analysis of individual frames, their components and cues.

———, and P. Kenneth Komoski. "Teaching Machines Can Aid the Schools to Make Better Use of Teacher's Time," *California Journal of Secondary Education*, 35: 252–54, April, 1960.

Teaching machines can release teachers for creative teaching. The next ten years we must decide if automated teaching, properly programmed, will become effective or be wasted by depending on the "hardware," to do a job only programs can achieve.

El Cojon Valley News, (California), February 25, 1960.

Dr. Robert E. Corrigan defined the goals of automatic teaching, defined a closed loop tutoring system and described two machines.

Falconer, George A. "Teaching Machines in the Deaf," *Volta Review*, 62: 59–62, February, 1960.

A review of the machines of Skinner and Pressey, together with a discussion of the place teaching machines can play in teaching the deaf is followed by a discription of an experiment using a machine similar to Skinners.

Fattu, Nicholas. "Training Devices," *Encyclopedia of Educational Research*, 3rd edition, New York: The Macmillian Co., 1960. Pp. 1529–35.

An overview of teaching machines is presented in this article which includes a historical outline, an analysis of the factors to be considered in development and programming, and research possibilities.

Ferster, Charles D., and Stanley M. Sapan. "An Application of Recent Developments in Psychology to the Teaching of German," *Harvard Educational Review*, 28: 58–69, Winter, 1960.*

Reinforcement is the key to effective learning, and the actual hardware is incidental.

Finn, James D. "Automation and Education: In General Aspects," *Audio Visual Communications Review*, 5: 343–60, Winter, 1957.

This a comprehensive review of the effect automation will have on our culture with brief comments relative to education.

———. "Teacher Understanding—Key to the New Technology," *CTA Journal*, 56: 5, September, 1960.

A plea for intelligent consideration of instructional technology is made with teaching machines offered, not as a panacea, but as an adjunct to the teacher providing greater efficiency.

———. "Technological Innovation in Education," *Audio Visual Instruction*, 5: 222–26, September, 1960.

Mr. Finn, pointing to the accelerated rate at which changes are being made in our culture, expects teaching machines to be an integrated part of education very shortly, inspite of programming difficulties.

———. "Technology and the Instructional Process," *Audio Visual Communications Review*, 8: 5–26, Winter, 1960.

This article is a philisophical and historical study of the impact of machine teaching on education. It discusses programming and implications.

Freeman, James T. "The Effects of Reinforced Practice on Conventional Multiple Choice Tests," *Automated Teaching Machine Bulletin*, 1: 19–20, September, 1959.*

A Pressey punchboard was used in a multi-faceted research project studying reinforcement.

Fry, Edward B. "California Steps Out with Teaching Machines," *CTA Journal*, 56: 14–15, September, 1960.

A statement of the principles which differentiate audio visual aids from teaching machines is presented with a current enumeration of machines being developed or in production.

———. "Mechanical Teacher," *Texas Outlook*, 4: 10–11, June, 1960.

———. "Teaching Machine Dichotomy: Skinner vs. Pressey," *Psychological Reports*, 6: 11–14, February, 1960.

Two diverse view points are explored, with respect to response made, step size, error permitted, learning theory and other factor. Conclusion. A lot of good experimental studies, theorical and applied are needed.

———. "Teaching Machines the Coming Automation," *The Phi Delta Kappan*, 41: 28–31, October, 1959.

Automation has become an integral part of our society and will become an adjunct of the classroom that provides for active participation by the learner and can be programmed for a diversity of materials, leading in small steps to effective learning. Pictures of six machines accompany the article.

———, and Glen L. Bryan, and Joseph W. Rigney. "Teaching Machines: An Annotated Bibliography," *Audio Visual Communication Review*, 8: 1–80, 1960.

Fry has compiled a comprehensive bibliography of teaching machines with extensive annotation covering the major aspects of the field. It also contains a bibliography of commercial machines.

Fusco, Gene C. "Technology in the Classroom: Challenges to the School Administration," *School Life*, 42: 18–23, March, 1960.

Emphasis is placed on the infancy of this area of study, on the extreme rate of growth of the field and on the lag in published material.

———. "Technology in the Classroom: Challenges to the School Administration Part II, Issues and Implications," *School Life*, 42: 20–25, May, 1960.

Administrative, economic and philosophic problems that will arise as new materials are introduced into the schools are considered.

Galanter, Eugene (ed.). *Automatic Teaching: The State of the Art.* New York: John Wiley and Sons, 1959. 197 pp.

This book is an excellent compilation of the thinking being done in this field. It reports on the December 1958 University of Pennsylvania Conference and provides a good reference point for the reader. Many of its papers are contained in this bibliography.

———. "Mechanization of Teaching," *National Association of Secondary School Principals Bulletin*, 44: 301–9, April, 1960.

Mr. Galanter goes back to Socratic Greece to find the roots of teaching machines. History, cost, programming and philosophical aspects are discussed along with the future of this new facet of education.

Gilbert, Thomas F. "An Early Approximation of Principles of Analysing and Revising Self-Instructional Programs," Paper presented at Conference of Teaching Machines, University of Pennsylvania, December, 1958.*

The teaching machine program, not the machine is the important thing. Gilbert classifies programming into eleven different areas.

———. "Some Recent Attempts at the Partial Automation of Teaching: A report to The University of Georgia," Unpublished paper, 1958.*

The author reports on the use of several teaching machines including one made of manila folders. It is the application of principles of learning that makes teaching machines effective.

Ginther, John. "Man, Values and the Machine," *Elementary School Journal*, 60: 179–89, January, 1960.

Glaser, Robert. "Christmas Past, Present and Future," *Contemporary Psychology*, 5: 24–28, 1960.*

This reviews Pressey, Skinner and Ramo.

———, Dora E. Damrin, and F. M. Gardiner. "The Tab Item: A Technique for the Measurement of Proficiency in Diagnostic Problem Solving Tasks," *Educational and Psychological Measurement*, 14: 283–93, Summer, 1954.*

In the use of the tab, the student selects the response he wishes to make and removes a tab to gain further information.

Greenspoon, Joel and Redge Ranyard. "Stimulus Conditions and Retro-active Inhibition," *Journal of Experimental Psychology*, 53: 55–59, January, 1957.

Greenspoon and Ranyard used a drum machine to teach nonsense syllables in a research study of retro-active inhibition.

Harcleroad, Fred F. "Books for Leaders: Prepare for the Debate," *Phi Delta Kappan*, 42: 30, October, 1960.

Both *Teaching Machines and Programmed Learning and Teaching Machines: An Annotated Bibliography* receive adequate reviews and encourage the reader to become informed.

Hechinger, Fred M. "Big Changes Coming in Education," *Parent's Magazine*, 35: 46–49, September, 1960.

A brief mention of this technique is made as a part of a larger over-view of changes which are on the horizon, including them teaching and changes in curriculum.

Henderson, Robert. "Listen, Son," *The New Yorker*, 35: 46–48, December 5, 1959.

This is a wonderful article about teachers the author has known who could never be put in a little black box.

Hirely, Wells. "Implications for the Classroom of B. F. Skinner's 'Analysis of Behavior'," *Harvard Educational Review*, Vol. 29, 37–42, Winter, 1959.

This is a theoretical discussion of Skinners principles of learning.

Holland, James G. "A Teaching Machine Program in Psychology," *Automatic Teaching: The State of The Art*. Eugene Galanter (ed.) New York: John Wiley and Sons, 1959, Pp. 69–82.

A specific program with sample frames is presented as used in an experiment. The technique appears very effective.

Homme, Lloyd E. (ed.). "Research Notes," *Automated Teaching Bulletin*, Rheem Manufacturing Company, 1, September, 1959.*

This bulletin summerizes research in progress, covering activities across the nation.

———. "The Rationale of Teaching by Skinner's Machines," *Teaching Machines and Programmed Learning*, Arthur Lumsdaine (ed.) Washington, D. C: National Education Association, 1960, Pp. 133–136.*

Skinner's Machines used to teach arithmetic, the programming and the importance of feedback are discussed by Homme.

———, and Robert Glaser. "Relationships Between the Programmed Textbook and Teaching Machines," *Automatic Teaching: The State of the Art*, Eugene Galanter (ed.) New York: John Wiley and Sons, 1959. Pp. 103–07.

The programmed textbook is machine teaching without hardware. The author believes it is effective and his experiences with it are outlined.

"How Machines Do Teaching," *Business Week*, 1620: 111–14, September 17, 1960.

This is a good review of the state of the art, the different philosophies and different machines available.

Huffman, H. "Will Teaching Machines Make You Obsolete?" *Business Education World*, 40: 11–13, February, 1960.

Hyer, Ann L. "The Old Order Passeth," *Audio Visual Instruction*, 5: 32, January, 1960.

The role of the teacher is explored in the light of the new technological trends.

———, and Robert C. Snider. "The Profession and the Machine," *CTA Journal*, 56: 6–7, September, 1960.

The challenge of the future and the changes to be wrought by predicted technological developments on elementary, secondary and teacher education are scanned.

Jensen, Barry T. "An Independent Study Laboratory Using Self-Scoring Tests," *Journal of Educational Research*, 43: 134–37, October, 1949.

A punch board device is incidental to this study, but is used to give the student immediate knowledge of his success or failure.

Jones, Robert Stuart. "Integration of Instructional with Self-Scoring Measuring Procedures," *Abstracts of Dictoral Dissertations*, No. 65, Ohio State University Press, 1954.*

The punch board and multiple-choice items achieve valuable instruction. Principles underlying their use are discussed.

Jones, Howard L., and Michael O. Sawyer. "A New Evaluation Instrument," *Journal of Educational Research*, 42: 381–85, January, 1949.

A report of the use of the Angell-Troyer punch board for classroom quizes indicates general favorable student response, improved learning and high motivation.

Keislor, Evan. "The Development of Understanding in Arithmetic by Teaching Machine," *Journal of Educational Psychology*, 50: 247–53, December, 1959.

Fourteen students were taught understanding of area on a Film Rater. The conclusions are that steps must be small, and explanations simple. The principles of programming are discussed.

———. *Theoretical Aspects of Automated Teaching*, Paper presented at Western Psychological Association, San Diego, April, 1959.*

Principles of programming and attributes of effective hardware are discussed.

Kindler, Howard. "Teaching Machines and Psychological Theory," *Automatic Teaching: The State and the Art*, Eugene Galanter (ed.) New York: John Wiley and Sons, 1959. Pp. 177–85.

An address devoted to the explanation of the effect experiments with teaching machines will have on the psychology of learning, particularly with regard to transferred symbolic processes.

King, P. E. "Teaching Machines and the Language Laboratory," *American School Board Journal*, 141: 17–18, August, 1960.

The possibilities for the solution of the "quality—quantity" problem is explored in a reasonable way with a cautious presentation pointing out benefits and hazards.

Know How, 11: 3, September–October, 1959. (Cover Picture)

Contact: A machine which lights when arithmetic questions and answers correspond.

Komaski, Kenneth P. "Origin of Collegiate School Automated Teaching Project," Unpublished Report, New York: Collegate School, February, 1960.*

Fifteen Rheem Machines and IBM Computer Lab are being used in this two year study developing programmed materials under a grant from the fund for the Advancement of Education.

"Learning Machine Tests Future Doctors," *Science News Letter* 72: 6, July 6, 1957.

A machine similar to Skinners is briefly discussed.

Little, James K. "Results of Use of Machines for Testing and for Drill Upon Learning in Educational Psychology," *Journal of Experimental Education*, 3: 45–49, 1934.*

A controlled study was made, and significant results appear using Pressey's multiple-choice machines.

Los Angeles Times, August 14, 1960.

This brief report outlines the use of the Auto-Tutor, a microfilm process with multi-track teaching.

Luce, Gay Gaer. "Can Machines Replace Teachers?" *The Saturday Evening Post*, 233: 36–37, September 24, 1960.

The advent of programming on the education scene, the research being done in colleges across the nation, the experimental programs and commercial teaching machines are all reviewed with an emphasis on the benefits to a burgeoning educational system.

Lumsdaine, Arthur A. "Partial and More Complete Automation of Teaching in Group and Individual Learning Situations," *Automatic Teaching: The State of the Art*, Eugene Galanter (ed.) New York: John Wiley and Sons, 1959. Pp. 147–66.

An historical and psychological review of automated teaching with an emphasis on the need for participation and prompting.

———. "Some Issues Concerning Devices and Programs for Automated Learning," *Teaching Machines and Programmed Learning*, Arthur Lumsdaine (ed.) Washington, D. C: National Education Association, 1960. Pp. 517–39.*

This is an extensive report about the machines in the field and research about them by a leader in the field.

———. "Teaching Machines and Self-Instructional Materials," *Audio Visual Communication* Review, 7: 163–81, Summer, 1959.

Mr. Lumsdaine reviews many devices in the field and indicates the use and limitations of each. Programming and needed research are also discussed effectively.

———, and Robert Glaser (eds.). *Teaching Machines and Programmed Learning: A Source Book*. Washington, D. C: Department of Audio-Visual Instruction, National Education Association, 1960. 724 pp.

This is the definitive work in the field. It is an impressive reference work, a comprehensive survey possible only because of the infancy of the field. All published works, and many unavailable unpublished and government documents are either included, or ably reviewed. Many of the articles it contains are reviewed here.

Mager, R. F. "Preliminary Studies to Automated Teaching," *Proceedings of the Institute of Radio Engineers*, October, 1959, p. 1790.

This is an introductory article to the field of teaching machines.

Mathieu, G. "Automated Language Instruction: A New Deal for Student and Teacher." *Automated Teaching Bulletin*. 1: 5–9; December 1959.

This article discusses the use of teaching machines in language instruction.

Mayhew, Donald J., and Arlo F. Johnson. "Teaching Machines," *Journal of Engineering Education*, 50: 51–52, October, 1959.

A machine similar to Skinner's advanced machine with branching is being used to teach engineering at the University of Utah.

Mellan, I. "Teaching and Educational Inventions" *Journal of Experimental Education* 4: 291–300; March 1936.

This article discusses patents and dates of patents on teaching machines. It lists patents under subject for which developed.

Meyer, S. R. "Report on the Initial Test of a Junior High-School Vocabulary Program." *Teaching Machines and Programmed Learning: a Source Book* (Edited by A. A. Lumsdaine and Robert Glaser). Washington, D. C.: National Education Association of the United States, 1960. p. 229–46.

This article describes a teaching machine program and is an investigation of elements in the design of teaching machines.

Meyer, Susan. "A Program in Elementary Arithmetic: Present and Future," *Automatic Teaching: The State and the Art*, Eugene Galanter (ed.) New York: John Wiley and Sons, 1959. Pp. 83–84.

A short, bitter article, indicating in briefest outline an apparently disappointing experience in introducing arithmetic to elementary school children using IBM Machine.

Morton, I. Rand. *The Language Laboratory as a Teaching Machine*. Paper presented at the Language Laboratory Converence, Indiana University, January, 1960.

Olds, R. "Automated Education," *Ohio Schools*, 38: 8–9, April, 1960.

Pask, Gordon. "Automatic Teaching Techniques," *British Communications and Electronics*, 4: 210–11, 1957.

———. "Electronic Keyboord Teaching Machines," *Education* and Commerce, 24: 16–26, July, 1958.

———. *Teaching Machines*, Solartron, Electronics Group Ltd., Belgium, Proceedings of the Second Congress, International Association for Cybernetics, September, 1958.

———. "The Self-Organizing Teacher," *Automated Teaching Bulletin*, 1: 13–18, December, 1959.*

New insights into the phenomenon of learning can be achieved through study of the interaction between man and machine teaching.

———. "The Teaching Machine," *The Overseas Engineer*, February, 1959. Pp. 231–32.

Peterson, J. C. "A New Device for Teaching, Testing, and Research on Learning," *Transactions of the Kansas Academy of Science*, 33: 41–47, 1930.*

The forerunner of Pressey's punchboard is described. Any technique which gives immediate knowledge of results contains the key element of a teaching machine.

Popp, Helen M., and Douglas Porter. "Programming Verbal Skills for Primary Grades," *Audio Visual Communications Review*, 8: 165–75, July–August, 1960.

The article presents an analysis of programming at the elementary level for a simple written response teaching machine, easily adapted to mathematics.

Porter, Douglas. "A Critical Review of a Portion of the Literature on Teaching Devices," *Harvard Educational Review*, 27: 126–47, Spring, 1957.

A comprehensive review of stimulus-response devices which have application as immediate reinforcers is presented along with a bibliography. This is an excellent study of available machines and their limitations.

———. "Some Effects of Year Long Teaching Machine Instruction," *Automatic Teaching: The State of the Art*, Eugene Galanter (ed.) New York: John Wiley and Sons, 1959. Pp. 85–90.

Spelling was programmed into machines and second and sixth grade students used the material for a year. Their progress as compared to control groups was superior. Samples are included in the report.

———. "Teaching Machines," *Harvard Graduate School of Education Bulletin*, 3: 1–5, March, 1958.*

Porter presents principles to be used in programming as utilized at Harvard, covering reinforcement, and prompts.

Pressey, Sidney L. "A Machine for Automatic Teaching and Drill Material," *School And Society*, 25: 549–52, 1927.

This article follows up the 1926 one and presents a machine which skips questions successfully answered. Pressey says he writes to stimulate activity in the field.

———. "A Simple Apparatus Which Gives Tests and Scores—and Teaches," *School and Society*, 23: 373–76, 1926.

This is the pioneering article in the field and is very interesting. It describes a machine which embodies all the attributes except branching and can even be adjusted to deliver candy as a reward.

———. "A Third and Fourth Contribution Toward the Coming 'Industrial Revolution' in Education," *School and Society*, 36: 668–72, November 12, 1932.

The author presents a rapid testing and scoring device which leads itself to item analysis, but touches on teaching machines as such only briefly.

———. "Certain Major Psycho-Educational Issues Appearing in the Conference on Teaching Machines," *Automatic Teaching: The State of the Art*, Eugene Galanter (ed.) New York: John Wiley and Sons, 1959. Pp. 187–98.

Teaching machines must be measurably successful in daily use with average students to warrant their use. Consideration must be given to such factors as: programming for fast students may inhibit learning by breaking subject material into discreet parts, or teaching specialized reading habits.

———. "Development and Appraisal of Devices Providing Immediate Automatic Scoring of Objective Tests and Concomitant Self-Instruction," *The Journal of Psychology*, 29: 417–47, 1950.

A careful study of the use of the punchboard as a testing-teaching device is presented with the results of controlled experiments. Reasonable conclusions are drawn. A bibliography is included.

Price, George R. "The Teaching Machine," *Think*, 25, 10–14, March, 1959.

This is an optomistic article which finds the solution to many of todays education problems in the use of the teaching machine. It presents Skinner's "Pavlovian" methods and indicates how prompt rewarding is reinforcing.

"Professor Skinner's Teaching Machine," *Fortune*, 58: 145, October, 1958.

A brief reference is made to the technique of the teaching machine in reference to greater educational productivity.

"Push-Button Brains," *Newsweek*, 54: 95, October 26, 1959.

A paragraph on Tutor has an accompanying photograph.

Ramo Simon. "A New Technique of Education," *Engineering and Science*, 21: 17–22, October, 1957.

Ramo envisions a new industry developed around teaching machines and programming in this country.

Rath, Gustave, Nancy Anderson, and R. L. Brainerd. "The IBM Research Center Teaching Machine Project," *Automatic Teaching: The State of the Art*. Eugene Galanter (ed.) New York: John Wiley and Sons, 1959. Pp. 117–30.

The IBM 650 is used to teach binary arithmetic, a very expensive, limited research technique. The program is outlined for the reader.

Reed, Paul C. "Machines for Your Future?" *Educational Screen*, 38: 636, December, 1959.

This is a brief consideration of what teaching machines may mean to the audio visual specialist in the school.

Reid, L. S. "A Review of *Automatic Teaching: the State of the Art*, E. H. Galanter, Editor." *Science* 131: 29–30; 1960.

The article indicates the great need for research. See title.

Robinson, Donald W. "But This A Machine Can Not Do," *CTA Journal*, 56: 16–17, September, 1960.

This is a statement of the limitations of mechanical and electronic teaching devices and the views of prominent men about the importance of the human element in teaching.

Rothkopf, E. Z. "The State of an Art?" *Contemporary Psychology* 5: 104–105; 1960.

This article is a review of *Automatic Teaching: The State of the Art*. The author finds much that can be criticised.

The San Diego Union. "*Teaching Machines*" *Get a Workout*. October 23, 1960.

Report on automatic teaching of mathematics in the Roanoke, Virginia, schools.

Schutz, R. E. "Progress and Preparation of Automated Instructional Material and Criterion Measures." Automated Teaching Bulletin 1, No. 2: 31–33; December 1959.

This article reports the results of an elementary arithmetic program involving automated instructions.

Silberman, Harry F. "A Computer as an Experimental Laboratory Machine for Research on Automated Teaching Proceedures," *Behavioral Science*, 5: 175–76, April, 1960.

The computor as a flexible machine allows for a study of the optimum methods of machine teaching. Extensive branching ability to tabulate time and error response and general adaptibility makes it a good research tool.

———. "Introductory Description of Teaching Machines," Abstracts, Symposium on Automated Teaching, Western Psychological association, San Diego 1959.*

An Analysis of the important concepts and components of the teaching machine is offered.

Skinner, B. F. "Teaching Machines," *Science*, 128: 969, October 24, 1958.

This is one of the more important articles in the field of teaching machines. It is comprehensive, dealing with the history philoospphy, hardware and programming and includes actual samples of materials.

———. "The Programming of Verbal Knowledge," *Automatic Teaching: The State of the Art*, Eugene Galanter (ed.), New York: John Wiley and Sons, 1959. p. 63–68.

Skinner presents some of the criteria of programming and presents an outline of a program for specific verbal knowledge.

———. "The Science of Learning and the Art of Teaching," *The Harvard Educational Review*, Vol. 24: 86–97, Spring, 1954.

The need for reinforcement in the learning situation and the role teaching machines can play, supplementing the teacher to satisfy this need is discussed along with the psychology of learning in this area.

———. "Skinner Demonstrates Teaching Machine," *Phi Delta Kappan*, 39: 18, October, 1957.

This is a brief report presentation of Dr. Skinners at the American Psychological Association meeting of September 1957 and describes the use of his machine.

Smith, Donald P. "Speculations: Characteristics of Successful Programs and

Programmers," *Automatic Teaching: The State of the Art*, Eugene Galanter (ed.), New York: John Wiley and Sons, 1959. Pp. 91–102.

An excellent paper on programming with specific examples and guiding principles. Also includes some of the author's "hunches."

———. "Teaching Machines?" *Michigan Education Journal*, 37: 461, March, 1960.

Smith, Karl V. "Audiovisumatic Teaching: A New Dimension in Education and Research," *Audio Visual Communications Review*, 8: 85–103, May–June 1960.

A projector and tape recorder are integrated with a student response device to stop presentation and await the correct response from the viewer. Its use and evaluation of its use is discussed.

Snider, Robert C. "DAVI and the Future," *Educational Screen and Audio Visual Guide*, 38: 644–45, December, 1959.

A report of the future plans of the Division of Audio Instruction, National Education Association indicates briefly, growing attention will be paid to teaching machines.

"Something Good Happens to a Child," *Phi Delta Kappan*, 42: 27, October, 1960.

A brief report is made about Skinner's remarks at the August Conference at the U. S. Office of Education. Teaching machines are beyond the experimental stage and their use is growing rapidly.

Spence, Kenneth. "The Relation of Learning Theory to the Technology of Education," *Harvard Educational Review*, 29: 84–95, Spring, 1959.

Teaching machines as immediate reinforcers belong in the classroom today. Research in programming is needed.

Stein, J. W. "Multiple Choice on Teaching Machines," *Overview*, 1: 74–76, June, 1960.

Stolurow, Lawrence M. "Teaching Machines and Special Education," *Educational and Psychological Measurements*, 20: 429–48, Autumn, 1960.

A survey of the history of teaching machines, a definition of what constitutes a teaching machine and a review of some aspects of programming are included. A bibliography follows.

Sturwold, Virginia G. "Teaching Machine Experts Visit Capitol," *Audio Visual Instruction*, 5: 254–55, October, 1960.

Sequential presentation is the forte of Auto-instructional devices (teaching machines) reported Dr. Skinner to the August Conference held in Washington, D. C.

"Talk of the Town: Tireless," *The New Yorker*, 35: 25–26, February 13, 1960.

The advantages of "Tutor" as produced by Western Design Division of U. S. Industries, Incorporated, are briefly presented.

"Teaching Machines," *The American Teacher*, 7: 4, September, 1960.

Machines can perform a function, but are really only useful supplements to the essential meeting of the minds between a disciplined teacher and an immature student.

"Teaching Machines, Education, and Job Skills," *Psychological Reports*, Vol. 5, No. 2, 1959.

A one-page overview of the teaching machine field. It surveys the work of Pressey and Skinner and makes a comment that the machine may revolutionize our methods of teaching.

"The Teaching Machines," *Time*, 76: 91–94, November 7, 1960.

Grolier Inc., publishers of The Book of Knowledge have come out with the Min-Max, a 7½ pound $20 teaching machine for which they have programmed seven subjects, $5 to $15. They expect to sell $5,000,000 worth the first year.

"Title VII, New Grants Announced," *Audio Visual Communications Review*, 8: 222–223, July–August 1960.

A list of recent grants for study by the U. S. Office of Education lists eleven of thirty-two in the area of teaching machines.

Twyford, Loran C. "Profile Techniques for Program Analysis," *Audio-Visual Communication Review*, 2: 243–62, Fall, 1954.

Describes a type of group feedback machine. While these devices are not exactly teaching machines, they do have some similar characteristics.

United Press International Dispatch, *The Aztec*, (San Diego, California), October 19, 1960.

Machines test while teachers give lectures reports on an electronic technique by which students may participate actively in television taught classes.

Weimer, Paul K. "Proposed 'Automatic' Teaching Device," *Institute of Radio Engineers, Transactions on Education*, E-1: 51–53, June 1, 1958.

The case for automatic teaching devices and proposals for machines to achieve his aims are presented.

Winebrenner, D. Kenneth. "Automation and Education," *School Arts*, 57: 48, November, 1957.

A refreshing editorial placing the teacher and the student back into proper perspective, is offered with numerous humerous remarks.

Wittich, Walter A. "Teaching Machines: Practical and Probable," *The Nations Schools*, 66: 64–5, August, 1960.

Electronically teaching machines are well developed! The real art lies in programming. It is necessary to understand what the possibilities and limitations of teaching machines are.

Wurtz, Roger. "Teaching Machine for Driver Education," *California Journal of Secondary Education*, 35: 301–04, May, 1960.

The Aetna Drivo-trainer, a teaching machine much like the Link trainer is discussed with the results of an experiment and cost comparisons presented.

Zeaman, David. "Skinner's Theory of Teaching Machines," *Automatic Teaching: The State of the Art*, Eugene Galanter (ed.), New York: John Wiley and Sons, 1959. Pp. 167–76.

An analysis of Skinner's theory of learning as it applies to teaching machines is adeptly presented.

———. "Teaching Machines," *Grade Teacher*, 78: 39, September, 1960.

This is a comprehensive review of the types of hardware in the field together with some knowledgeable remarks about use and programming.

Zschokke, Theo. O. " 'Mr. Brain' Helps In Classroom," *CTA Journal*, 56: 13, September, 1960.

An author developed teaching machine for drill activity at the elementary level is described.

JOHN HAY FELLOWSHIPS FOR 1962–63

Public senior high school teachers from twenty-six states and the District of Columbia are invited to apply for John Hay Fellowships in 1962–63. Winners of these awards will study in the humanities for a year at one of the following Universities: California, Chicago, Columbia, Harvard, Northwestern, and Yale. They will receive stipends equal to their salaries during the fellowship year. In addition, the John Hay Fellows Program pays the travel expenses for the Fellow and his primary dependents, his tuition, and a health fee.

A total of seventy-five fellowships will be awarded. John Hay Fellows will be selected from schools and school systems interested in making the best possible use of the time and talents of good teachers and in developing practices designed to break educational locksteps.

Applicants shall have at least five years of high school teaching experience, and should not be more than fifty-five years of age. Languages, Literature, history, music, and the fine arts are usually included in the humanities, and teachers in other disciplines who wish to study in the humanities are accepted.

Teachers interested in applying for John Hay Fellowships should communicate with Dr. Charles R. Keller, Director, John Hay Fellows Program, 9 Rockefeller Plaza, New York 20, New York. Applications will close on December 1, 1961.

Illustration, Discovery, and Proof

S. D. Holmes

Toronto, Ontario, Canada

A successful comedian rarely begins a joke by giving out the punch line and then relating the anecdote. The author of a detective story is not likely to start his book with a statement that the butler did it with his corkscrew. But look at these three statements introducing experiments in science!

This experiment will show that air has pressure. (*Elementary School Journal*)

To demonstrate that plant leaves make food, but that this process requires light, carbon dioxide, green tissue, and water. (*The Science Teacher*)

To show that water pressure increases with depth. (*Unesco Source Book for Science Teaching*)

These quotations, to which hundreds of others could be added from textbooks and official courses of study, as well as from periodicals, indicate the need for a reconsideration by teachers of the proper aims and purposes of instruction in science. Besides being faulty as statements of purpose, these examples also point to misapprehensions in what ought to be achieved in experimental work, and in how its results ought to be interpreted.

In his book, *Science and Common Sense*, James B. Conant suggests two aspects of science, that might be condensed into two short phrases, "systematized information" and "a speculative enterprise." We are, as teachers, concerned with transferring to our pupils as much as possible of the accumulated body of facts, theories, laws, and discoveries that constitute our present scientific knowledge. We are also required to prepare and train our pupils for investigation and research so that some of them can accept their roles in the speculative enterprise which in the future will continue to enlarge the horizons of science.

Looking at the first of these two requirements it is obvious that some experimentation should be designed to help our pupils to understand principles and to remember details. The "experiments" are like the illustrations in a book or magazine article. The intention is to explain the text, to turn the abstract into the concrete, to provide a visual clarification or reinforcement of an idea, to summarize a lengthy process, or any one of a dozen other purposes. There are a great many forms which illustrations and their captions may take, but surely, it must be agreed that the best illustration is the one that presents all the relevant facts most clearly and completely; also the best caption is the one that draws attention to the significant details

but leaves the reader free to make his own observations and draw his own conclusions. Of course illustrations, like TV programmes and moving pictures, can be so constructed as to do all the viewer's thinking for him just as newspaper headlines can be devised to save the bother of reading the news item. But there is no reason why experiments, even if they are intended only to supply information, should give the whole show away before the curtain rises. Instead of proposing to show, as details to be merely checked or verified, that air has weight or exerts pressure or is composed of oxygen, nitrogen etc., why not study the properties of air and let them develop by discovery from the experiment and organize themselves as related parts of a complete picture?

When we come to the other aspect of science, the training in independent investigation, the weighing of evidence, the drawing of justifiable conclusions, it becomes most obvious that statements of purpose like the one that tells the whole story of photosynthesis are completely out of place. They are not only out of place, but they positively defeat their own ends. If an investigation in the field of plant nutrition is to be undertaken it should be begun with an open mind, without preconceived ideas. Kinds and sources of food materials, possible mechanisms for securing these requirements, locations and suitable conditions for the operation of processes, evidence of the formation of by-products, all these require consideration, planning and investigation. When all the evidence has been accumulated it must be evaluated so that a general conclusion can be drawn. In other words the pattern of a real piece of research ought to be followed as a vital experience and training for the pupils. It may of course be necessary, because of the time element as well as for other considerations, to give the class some guidance and eliminate some of the non-productive lines of investigation. But essentially, it should retain the characteristics of an original research project. It cannot do so if the conclusions are incorporated in the statement of purpose.

Another error in stating the purpose of an experiment, and in interpreting the result, is suggested by our third example,—the assumption that a single, simple experiment is going to prove any physical law. The proof that water pressure increases with depth does not rest on two observations made with a gauge held at depths of six inches and twelve inches, but on thousands of observations made for many different depths and under all kinds of conditions. Would it not then be better to express the purpose of our experiment as intended to see if we can find any relation between pressure and depth? Our conclusion would be simply that our results seem to confirm the established law, followed by an accurate statement of the law.

Similarly, a class experiment with some magnets does not prove

the law of magnetic attraction and repulsion. It only warrants a statement about those particular magnets under the limited conditions of that isolated set of experiments. It may provide additional confirmation of a generalization which was reached after a great many previous experiments with all kinds of magnets under a variety of conditions. Or, it may be considered not as proving but as providing an illustration of the law. Yet again and again in elementary textbooks we get the assumption that a law is thus easily proved.

The idea of the nature of scientific proof and the importance of exactly expressed and carefully limited generalizations are concepts that need to be thoughtfully and thoroughly taught. The difference between the logical proof of an exactly enunciated proposition in geometry and the kind of proof required tc turn a theory or hypothesis into a scientific law or principle is not easily grasped. But, it is a distinction that needs to be fully appreciated by every serious student of science. In this same connection, the mutable, rather than the absolute, nature of scientific laws and definitions is another phenomenon for which pupils need to be prepared. Under the impact of new discoveries old ideas require modification. Many senior teachers will remember how absolute the definition of a chemical element used to be, and how immovable the barrier between mass and energy, each with its own law of conservation, before atomic fission became a commonplace. A reservation is not a bad thing in any attempted generalization. Hedging if you like! Undoubtedly the future will reveal many adjustments to be made in the presently accepted scheme of things and our pupils will need open as well as enquiring minds.

Three examples of faulty statements of purpose have been examined. They illustrate the need for a closer idea of what we are trying to do in our classroom or laboratory experimental work; the need for a more careful and exact use of English in describing that work; and the need for a better understanding and interpretation of the meaning of the results, scientifically speaking.

PROBLEMS OF RESEARCH AND IMPLICATIONS IN TEACHING SCIENCE

In the past, it has been the privilege of SCHOOL SCIENCE AND MATHEMATICS to publish the reviews of research presented at the Research Symposium sponsored by the National Association for Research in Science Teaching at the annual convention of the American Association for the Advancement of Science. Once again the Editor is pleased to present to the readers of the journal the papers presented at the most recent AAAS meeting. The three papers that follow were read at the NARST-AAAS meeting in the Roosevelt Hotel, New York City, December 27, 1960.

Problems of Research and Implications in Teaching Science in the Elementary School

Cyrus Barnes
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Research in elementary science teaching is not a recent development; nor has science in the elementary school been associated in recent years with greatly broadened or intensified research, or large-scale new approaches in research. But much has been accomplished, enough to point the way to areas and directions of apparently high potential for research that can make a profound difference in improving teaching and learning in elementary school science.

Early research in elementary school science goes back at least to the 1890's, as reported at the meeting corresponding to this one a year ago. In the interval roughly dated 1890–1920, the relatively few researches discovered problems of elementary science teaching, measured status as to how much about what topics was being taught, and identified children's interests through oral and written questions.

The problems of teachers and supervisors listed almost ¾ of a century ago included some of current interest:

how to teach so children will have more exercise in thinking things out independently,

how to get elementary science teachers to include more experiments and demonstrations, and more use of concrete illustrative materials in their science lessons,

what to do about the orientation, almost without exception, of teacher training toward other than science learnings. The apparently resultant lack of teacher interest in science seems to have been as baffling to the supervisors as the lack of knowledge of science.

The early study of status as regards topics studied and amount of time given to science instruction shows a wide variety of topics, preponderantly biological, and also reveals that many communities had no elementary science at all, while others were dissatisfied with their science teaching but were doing nothing to improve it.

The early analyses of interest indicate that children's interests as measured by oral and written questions vary widely, and that the means of eliciting the questions seem to have encouraged certain questions and discouraged or excluded other questions.

The sources of data in these early studies included: correspondence with school administrators, children's written questions, and children's oral questions. Data from the latter—oral questions—were gathered in elementary classrooms during and closely following science lessions, obviously a good time and place, perhaps even the best time and place to obtain evidence on learning in science.

The foregoing can be associated chronologically and perhaps generically with the Nature Study Movement. The same years show the Junior High School established as meeting a need in American Education, and General Science developed to meet a perhaps more fundamental, lasting need.

In the years of the 20's through most of the 30's, elementary science replaced nature study rather widely, though in some places probably more in name than in fact. In these years the amount of research increased greatly, including numerous studies in elementary science education. In rough classification, these researches could be stated to deal with:

courses of study,

principles of science, listed for purposes of curriculum making, comparisons of methods of teaching science,

and

specific aspects of learning, e.g., pupils' abilities to generalize.

In these years the psychological, physiological, and pedagogical study of child development increased very much and the activity movement in elementary education earned recognition. The research by Gerald Craig presented a course of study which, together with the methods used in its development and the books which implement its use, has influenced profoundly elementary science teaching both locally and nationally. Research by F. D. Curtis showed relationships between general reading and learning in science. The writings of E. R. Downing on elements and safeguards of scientific thinking, together with the researches of Craig and Curtis just mentioned, gave new and strong emphasis on improved thinking and feeling about science, and about life, as goals of science instruction. This is suggestive of and thoroughly consistent with current emphasis on process in science teaching.

In these years also the committee for the 31st Yearbook, with something less than full unanimity, at least in their respective chapters, endorsed the using of principles of science as the major items in the plan of organization of curricula in science. At the U. of Michigan and elsewhere numerous researches produced lists of principles suitable for use in curriculum work at various grade levels, including elementary.

Studies comparing methods of instruction have appeared from the 20's until the present. In the 30's and later such studies supported strongly the general conclusion that the less tangible goals of science instruction, e.g. growth in skill in problem solving, are actually functional in that lessons planned to bring about growth in attainment of such objectives can cause such growth to take place, within the limits of the tests used. A secondary achievement of such studies is the tests that were developed by some of the investigators to measure learning with respect to specific objectives.

Still other studies of these years have dealt with aspects of thinking or problem solving, including concept formation, and generalization. In both cases conclusions were based on children's oral and written responses.

Sources of data used in these years include the growing professional literature, pupil scores on a wide variety of examinations, answers to questionnaires received from laymen, educators, scientists, students and perhaps others, and the free, unstructured writings of children, used, for example, to find out whether children make generalized statements regarding a group of demonstrations dealing with a common principle.

Two problems appear to threaten the effectiveness of the research in elementary science teaching of these decades and to be even more important at present: These problems are associated with professional communication and with our fundamental *concept of learning*.

Communication of the barest essentials—*Problem*, *Methods*, *Findings*—of a study often, in fact usually, is not adequate, especially if the study involves a comparison of methods of instruction, or evaluation of learning by other means than published examinations. This seems to be true whether the research is reported in an article in a professional journal or on one of the forms from the U. S. Office of Education, for later reporting from that office to the public. And how often in summaries or analyses of research one finds reference to unpublished research. Such a lamp is so truly "under a bushel."

Especially in reports of research involving evaluation of learning, the evidences of learning should be explained fully, at least as to kind, and preferably to degree. Sometimes a report reveals that a test of achievement in a specific objective was constructed and used. Such a statement may be relatively meaningless until the objective

is defined in its present usage and a statement is made about the validity and reliability of the test which was constructed.

The problem of criteria of learning is probably more urgent in these recent years in which national and other leaders who are not educators, especially scientists, have been evaluating, analyzing, and generally reacting to courses, curricula, books, facilities, instruction, and learning in elementary science.

Is recall the principal criterion of learning? If so, is it to be verbatim? Are there degrees or levels of recall? Is transfer a better criterion? If so, for what evidences of transfer shall we look? Is behavior a still better criterion? If so, what classroom and laboratory behaviors, if any, are significant? Can questionnaires or tests reveal actual past, or probable future, behaviors?

The interval between the late 30's and the present has brought greatly increased research, with more sophisticated statistical treatment of data. No new gross categories are seen, but new and improved tests are in use, measuring with more validity various specific aspects of learning in science. Of special significance is the improvement, by West and Hill and others, of ways and means to observe and record children's classroom behavior, mainly verbal, and to draw inferences concerning children's thinking. These and other studies in which data from direct observation of children in classrooms as by Atkin seem to the present reporter to have very high potential for improving instruction in elementary science. Such studies seem to get closer to the heart of things, closer to the center of the learning process. They do not take the place of, or remove the need for, studies directed toward determining the status of education, toward finding a consensus, or toward identifying trends. It does seem, however, that a moderate de-emphasis of the questionnaire would be in order, especially if the energy so rechanneled would achieve more insight into the nature of learning in science. The need for study of learning is emphasized in the 59th yearbook, following a vigorous analysis of progress to date in this area.

Of current needs for research in elementary science, the need for better understanding of the nature of learning is most important, most fundamental. On our interpretation of how children learn stand our decisions as to selection of content, organization of content, what facilities and equipment are needed, what methods of instruction shall be used, how to evaluate results of instruction, and a host of other matters, including the use of the textbook, of the laboratory, of demonstration, visual aids, and T.V. Our understainding of learning is not unrelated to public relations and the P.T.A.

We need to know what sorts of verbal and written responses are

evidences of learning, how, for example, the questions of ten year olds usually differ from those of 7 year olds.

How can classroom behavior, presumably largely spoken words, be more fully identified, recorded, and analyzed to reveal evidence of learning, preferably learning in relation to specific instruction or to specific educational objectives?

A related current need is for better bases of evaluation of learning—for better criteria of learning. Recall, transfer, and behavior have been mentioned, but the only one of these which we handle well is recall. We have had much research, though largely with secondary school pupils, comparing methods of instruction, frequently resulting in definite conclusions by the investigator that certain methods are superior. Have many others changed their methods of instruction as a result of such research? It appears probable that few have done so, possibly because the results are not convincing. This may be due to inadequate communication. The reader may not be able to deduce from a brief report just how the investigator reached his conclusions. But a second general weakness of research in science education stands out, namely its need for rechecking, for independent verification. Most of our research is used to meet degree requirement and is required to be rather completely dissimilar to previous research. We must find ways to recheck our research.

Another facet of the learning problem involves need for better understanding of learning in relation to process in science, process in the sense of how scientists have achieved, and involving at least a minimum of planning and doing by children, in addition to the usual reading, and listening to the teacher. Process, or critical thinking, seems to be related to understanding, to feeling, and to behavior, and the measurement of pupil growth toward the process goal may require evidence that he *knows* about science or a phenomenon, and, to an extent, how he *feels* and how he *acts* with relation to the phenomenon. Process is dealt with at length in the 59th, and, in synonymous terms, in the 46th and earlier yearbooks.

Since textbooks are largely expository, the question may be raised as to how pupils should use a textbook, which tells the answers to the questions it raises, to help them think their problems through to satisfactory solutions.

Are there levels of sophistication with regard to process which should become the goals of science instruction at different ages or stages of development? If so, what are their characteristics? How do children tend to speak, write, and act when they are on or near each level? If new research identifies such levels, how necessary will be suitable means of communication to carry such news to the teaching public, possibly a job for tape, film, or T.V.

Need for research exists currently to test new proposals for improvement in elementary science. Blough in a recent yearbook wrote penetratingly of integration of social studies and science in elementary teaching. A curriculum study in this regard might be helpful. The proposal for departmentalized instruction in the elementary school, with a science specialist in a science-equipped room teaching all the elementary science raises fundamental questions concerning scientific literacy and general education, especially the question as to whether teachers should be competent in all curriculum branches, and particularly so in science in the present age. Such a problem would be more difficult but not impossible to explore on a research level.

We need to validate our purposes; tiresome as it may seem to some, we need to refine our definitions, and thereby our concepts. To this reporter, such definition will move us toward science as theory, not merely description; toward science as explanation of interrelated phenomena, not as explanation of technological devices. This makes of our content goals more than words and topics; they become ideas and interrelationships and interpretations; they tell us how we know and explain.

Our research needs better organization, better channeling into areas of high potential for constructive results. As aids to research, as many in this audience know, the N.A.R.S.T. and the U. S. Office of Education have developed an extensive list of issues in science education, which are suggested areas or clusters of topics for research in science teaching. Also the same sources produce, and the Office of Education publishes, the Biennial Surveys of Research in Science Teaching. These are designed to serve the professional public and especially persons interested in planning or conducting research.

The needs for research mentioned herein are not new, nor unique to this decade. But they are more urgent than ever before because of the rapid changes in our society. This may sound pessimistic but established school programs have been very slow to change, and it may be that elementary school science programs currently being established will, when once crystallized, be little affected by research of ten years hence. In many communities the current strong interest is more in getting an adequate program into action than in developing a program superior from its inception.

We have perhaps taken for granted the bases of our theory and practice in elementary science teaching in the past. Now scientists seem about to move in and suggest changes without regard for our opinions although the proposed changes are also based on opinions. How much better for education if sound bases for improvement can be developed through research in time to meet present needs.

Educational Research and Science Education

Hubert M. Evans
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Our concept of educational research and its function in relation to progress in science education constantly need clarification in the light of changing conditions in education and in the environing society. That educational research has not been a central or determining factor in the development of current science programs in the secondary school needs no documentation. That science teaching remains largely a practical art uninformed by sophisticated empirical research, or a body of relevant theory, also needs no documentation. This is not to say that present practices and programs have exhausted educational theory, or the existing body of reliable knowledge about educational processes. This is clearly not the case. As science educators, we are not doing as well as we could if we were aware of existing knowledge and theory and undertook seriously the professional task of testing such knowledge and theory in school and classroom situations. The vigorous prosecution of educational research on many fronts is necessary for the development of a profession of education. It is of great importance at this time in science education. Again we stand at a crossroad; a crossroad generated by the widespread belief that education in science is essential to the achievement of national and international goals directed to the improvement of human life and living.

Science Education—A Social Necessity

Even a superficial look at what is going on today in science education would reveal a striking phenomenon; extensive public concern for the quality of science education in the schools. A conclusion seems inescapable; it is widely held in American society that science is an essential element in the program of school studies. If education in science is indispensable to our society, as I believe it to be, it is so not only because of its utilitarian value but also for ideological reasons. The inclusion of science in the school program may be seen, as it is by many, as an essential ingredient in a "better education," and the better must be gauged in ideological terms: democratic ideology with its open political system, its concern for the individual, for the good life, for the good society. Progress toward the achievement of our most humanistic aspirations is in no small measure dependent on the accessibility and the quality of the science programs in our schools; progress not only in a material sense but also in the sense that science as an intellectual enterprise is an "open system" compatible with democratic ideology, and when taken together, as some

believe, constitutes a prototype of the "open society" which must prevail universally if we are to achieve a genuine world community.

Stressing these points, I believe, heavily underlines the great importance of science and science education in modern societies, and for the emerging world community. And in emphasizing these points, I have in mind not only the hundreds of thousands who will have to be educated and trained as specialists and competent workers in science and technology, but also the tens of millions who will have to be educated to participate effectively in a scientific and highly technical society. It seems to me almost inconceivable that this tremendous task can be carried forward effectively and at a rate commensurate with need, with present science programs and teaching methodolgies. Major innovations in science education at all levels will have to be worked out, and if this is to be done intelligently and with foresight, maximum use of the research approach (scientific inquiry) and research techniques will be required. It is of utmost importance that we do not underestimate the dimensions of the job to be done in science education during the next ten or fifteen years, not only in our own country but throughout the world.

Educational Research: Some Problems

The case for educational research as indispensable to progress in education has already been hinted, and the observation made that research has not played a major role in the development of science programs from the Committee of Ten to the Physical Science Study Committee. No doubt, the same could be said of other teaching fields and of formal education in general. It may be useful before going on to inquire why educational research has not played a more potent role than it has as a social instrument for advancing the effectiveness and worth of formal education. There are, among others, three major reasons for the present low status of educational research as compared with the status of research in other professions; medicine, for example.[1]

First, no one will have difficulty in recognizing that lack of time, money, and skilled personnel are chronic ailments in educational research. The costs of even modest research ventures are relatively high, and the brute fact is that in any given year only a tiny fraction of the total national budget for education is expended on research. On the other hand, the cost of not doing the kinds of systematic and creative research which have known potential for improving educational processes may cost many times the amount of money, time, and energy we now spend on research. As suggested in the Unesco

[1] UNESCO, *Report of the First International Conference on Educational Research* (February 1956). Educational Studies and Documents, No. XX. Unesco Publications Center, 152 West 42nd Street, New York 36, N.Y.

report, we must find ways to document the reality of these losses and to get a wide hearing for our story.

A second major reason for the paucity and often low quality of educational research is the well known lack of a body of adequate theory to guide research design, and research efforts on the fundamental problems in education; school learning and curriculum construction, for example. This is an internal problem which will have to be resolved, if at all, by the specialist in educational research aided by advances in social and psychological theory.

Finally, the widespread lack of faith in the effectiveness and worth of educational research is a fundamental difficulty. For many educated people, the coupling of "education" and "research" is meaningless and, at best, a paradox. There exists a lack of awareness of the need for educational research and its importance, among the educated public and among educators. Educational problems above the level of routine technique seem to many to be too complex for the kind of research that could lead to reliable results. These beliefs flourish despite the fact that over the past fifty years the findings of educational research have at times profoundly influenced educational concepts and practices.

Educational research surely warrants a better fate than is now the case when one takes into account its achievements and known potentialities. Obviously, there is a need to build a solid reputation for educational research, and this is more likely to occur if ways and means are found to establish a "research community" within the profession of education; a community with its own ethos and institutional mandates binding on all those who engage in serious educational research. Then, and perhaps, only then, will it be possible to eliminate the trivial or unmanageable research project and the publication of inconclusive results or misleading interpretations which have in the past added little to the status of educational research. It is encouraging to note that recent developments in the AERA seem to be moving in this direction.

Research in Secondary School Science Education

Despite the many difficulties which encumber the progress of educational research, it is imperative that we continue and step-up our efforts to carefully design and execute research studies which will give detailed guidance to our problem solving at every level of operation significant to the improvement of science education in the schools. Among the many needed investigations that could be listed, the following types of research studies seem to me to be particularly important at this time.

1. Comparative, analytical studies of the typical subject matter

of the different sciences seeking to throw light on their structure and key concepts, and how the results of such analyses may be so interpreted as to effect constructively teaching and economy in learning. Perhaps we need a new set of categories for organizing science content for teaching purposes at the secondary school level. The traditional divisions of science which now prevail in the schools (physics, chemistry, biology) may be less useful than they formerly were. And we need to examine rather critically the assumption that fairly narrow specialized courses in science are more likely to achieve basic objectives in science teaching than any species of general course. Courses designed for general education purposes come and go and no one knows why they came or whither they go. These sorts of studies will require the services of the specialist in science, the philosopher of science, and the experienced science teacher.

2. A series of inquiries into the relative merits of different plans and proposals for adjusting science instruction to individual differences and needs—ability groupings, special classes, acceleration operations, enrichment programs, and the like. It is thought-provoking that so few of the "experiments" directed toward solving this general problem have involved a valid research approach, or have been based on the findings of past research. Here will be needed the specialist in educational research and the seasoned science teacher.

3. Studies of the language problem in teaching and learning science. Gaining access to scientific knowledge and putting it to use is largely a problem of mastering the language of science, and this is by no means merely a matter of vocabulary. Learning to think scientifically requires learning how to use language in certain ways following established rules and procedures. It requires learning how to formulate and criticize scientific propositions using agreed on criteria. Prosecuting studies of this sort will involve the philosopher, the science specialist, and the experienced teacher.

4. A number of related investigations of the new developments in the science and art of programmed instruction, including the so-called "teaching machine" as a minor accessory. With respect to the bearing of programmed materials on classroom teaching and self-instruction, there is a need to separate "the weeds from the corn" and to move as quickly as possible to capitalize on the considerable potential in the concept of scientific programming for the improvement of learning in science. The types of research needed here will require the research specialist in education and the experienced teacher.

5. Finally, we need to investigate the science teacher as a professional worker—his personality, his commitments, his outlook on life, his point of view toward his job—in order to throw some light on the relation of personal characteristics to effective science teach-

ing. In addition, studies of the science teacher as a program maker, as an intelligent planner, would be appropriate at this time. While it is true that science teachers have always been involved, more or less, with outside directives with respect to what to teach and how to teach it (texts and courses of study), the recent stepping-up of these accepted practices in the form of "packaged deals"—on paper, electron beams, or film—should alert us to the problem of what is happening to the ability of the science teacher to program his own work intelligently and to discharge his professional responsibilities in the situation where he works. The manifold pressures on the science teacher from both inside and outside the formal school structure have tended to reduce him to the level of a technician with little autonomy and, consequently, little if any voice in policy. The heightening of this tendency may well result in making the science teacher less and less able to make intelligent and effective use of what others have planned in detail. For studies of this sort, will be needed considerable expertness of the sort which probably could be furnished by the trained psychologist and the specialist in educational research.

Designing and prosecuting research programs and research studies adequate for present needs in science education will require specialists in educational research and a wide diffusion of research attitudes and basic research techniques among science teachers. We must train a much larger number of research specialists than is now the case, and provide the opportunity and resources for them to work on important problems on a full time basis. It is also essential that we train all science teachers in the elements of educational research, and this can be done as a part of existing programs for the education of science teachers. This does not imply that we should expect the classroom teacher to make new discoveries in education, but it does imply that the science teacher should be equipped to follow up discoveries intelligently and thus increase the probability that he will improve systematically the teaching and learning for which he is responsible. We should not underestimate the considerable difficulties which lie in the path of the science teacher who attempts such a task. The demands and pressures on all teachers, inside and outside education are, more often than not, in the direction of conformity rather than toward creative innovation and change. The systematic pursuit of discoveries in education and their follow up in the classroom implies a major institutional goal: the institutionalization of innovation and change in the formal structure of the educational enterprise.

Summary

No doubt, a halo of impracticality hovers over the proposals in-

cluded in this paper, especially as judged in terms of the immediate future. But we must look ahead twenty or twenty-five years keeping in focus the major objective implicit in this discussion: the institutionalization of research within the educational enterprise. There is no *a priori* reason to believe that a great increase in educational research on many fronts would not result in advancements in education comparable to those achieved in engineering or medicine. There is no rationally determined principle of impotence which excludes such a possibility, although such principles are dogmatically asserted from time to time. Education as process is both a practical art and an applied science. If we are to make steady progress in improving the "art," we must cultivate assiduously the "science." This conclusion should come easily to the educator trained in the natural sciences.

Problems of Research and Implications in Teaching Science on the College Level*

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Unless the American government initiates financial support for research in how to improve the teaching of the natural sciences, we shall continue to have a shortage of scientists and other technical personnel. A mere attempt has been made to improve the teaching of the science information through very few projects supported for the purpose of making the information more up to date on the college level. Thousands of potentially talented science students are chased out of the sciences because of lack of knowledge of how to make science inspirational and appealing to great numbers of students.

In recent years, elementary and secondary schools have initiated programs that encourage able science students even though much research is still needed. On the college level, there is much neglect in this area. It is a serious waste of manpower when one is informed that in a class of 800 freshman engineering students, only 150 graduated as certified engineers as revealed by the dean of the School of Engineering at Louisiana State University.

The implications for research in solving this problem deal with investigations to determine how college professors can give sound guidance to prospective scientific and technical students. What amount of time, if any, is spent by professors of science in determin-

* Presented as part of a Symposium sponsored by the National Association for Research in Science Teaching in co-operation with NABT, NSTA, and ANSS at the New York meeting of the American Association for the Advancement of Science, Dec. 27, 1960.

ing which students show excellent potentiality in becoming scientists or members of a scientific profession? Several attempts were made to design tests that determine aptitude in science. Additional research is needed to measure the drive and persistency in completing intellectual tasks and their relationship to achievement in scientific knowledge and scientific careers. Perhaps less attention should be given to intelligence quotients and greater stress should be given in understanding how students learn science and their motivation.

How do college students learn scientific understandings and retain them in being able to solve problems? Several important research studies could be designed to indicate the type of learning and teaching that is required to teach students to apply scientific knowledge to solving problems. Students may be able to memorize Charles' or Boyle's Laws and yet be unable to solve a problem involving the gas laws. If some students are able to solve such problems, they may not necessarily be able to apply such knowledge in knowing what to do when the tires of an auto are over-inflated on a hot summer day. To what degree do college science courses emphasize learning science for the ability to solve scientific problems? This deficiency causes many students to lose interest in science and may occasionally discourage bright students from continuing in the natural sciences. Students do not automatically learn how to make applications unless they are given specific learning activities such as experiments that represent applications of scientific principles.

How do college science teachers' attitudes affect the learning of science by college students who plan to enter the scientific professions? For example, if a professor of chemistry warns that 40% of the freshman class will fail the introductory chemistry course at the first class meeting, how do such statements influence, if at all, the learning of chemistry? How do science professors affect learning and student attitudes when they feel they should only lecture to students without knowing them as individuals? Perhaps a serious examination of the lecture versus other procedures in the teaching-learning process needs to be done on the college level more so than on the public school level.

Are college students in science able to perform and design creative experiments or are they still following the cook-book recipe plan of laboratory work? Should college chemistry or physics students perform 30 experiments in the laboratory or will fewer, more creative experiments be more desirable? Can educational research indicate the effects of an open-ended laboratory type of experiments? Why aren't college professors in the sciences informed of latest research such as how to teach college chemistry and physics by the inductive-deductive method rather than primarily by the lecture plan?

Shouldn't educational research be sponsored and supported to determine how college science can be taught to change or improve overt behavior in students? As an illustration, the professor of biology may state excellent reasons why one should not smoke or merely list the harmful effects of smoking cigarettes. Another professor will discuss the physiological effects of smoking in terms of circulation, the heart, the lungs and other organs. Yet, the same students who were subjected to such scientific knowledge will usually continue to smoke. The act of giving up cigarette smoking is a change in overt behavior that is not performed on mere listening to scientific information. Yet, science professors do not know how to teach science to modify overt behavior. Another example might be the use of scientific knowledge in nutrition. Knowing the proper foods that are required for good health does not necessarily insure that one will select foods in terms of what's needed for good health.

How can we produce a type of science and science student that will help make science students more scientific by showing less prejudice? We know how rigidity as a trait in personality hinders one's ability to think scientifically or solve problems in an objective manner. No studies are utilized to an appreciable degree by college teachers in causing a change to reduce or eliminate student prejudice. Science can make a worthy contribution towards the betterment of world understanding and world living in peace and harmony. Applied educational research, however, is needed to provide the means by which this kind of teaching of science can be accomplished.

For all college students in a liberal arts program who do not intend to specialize in the sciences, no research is done to determine how to teach science and its social and economic implications. A few studies have provided us with some criteria in the selection of scientific principles for purposes of general education. Nevertheless, one seldom finds college science instruction which is based primarily on the development of the objectives or such criteria. Specifically, should all intelligent citizens be required to know the biochemistry of the gene in studying elementary college biology or should this be reserved for the student who plans to specialize in biology? Should colleges offer at least 2 kinds of biology courses for beginning students or is one "good" course in biology sufficient to meet the needs of both the major and non-major in science? Educational research should be directed to solving some of these critical issues that could very well influence the future quality and quantity of scientists.

Do non-science majors and college graduates have an intelligent basis for voting on such issues as support, use or misuse of radioactive fallout, atomic energy, fluoridation of water, pasteurization of milk, antibiotics, and other scientific developments? How can the teaching of science provide this necessary knowledge and behavior?

A few attempts have been made at Harvard, Michigan State, Antioch and other colleges to develop a strategy for teaching science for critical thinking. Case study techniques, historical studies in science, and applications of scientific principles are evaluated by students and professors with the hope of developing critical or analytical thinking in science. Along with the development of reflective thinking, students need to be encouraged to perform and design experiments. To stimulate this inductive and deductive reasoning, students should be expected to have trial and error activities and to learn that making mistakes constitutes a vital part of the scientific thinking process. How the learner learns to think creatively in science should be given more serious attention than the mere memorization of facts alone. To what degree do the history and philosophy of science remain with general education students in comparison with scientific principles? These are specific studies that should be supported to promote a more effective science teaching program in American colleges and universities for our health, prosperity, and security.

THE ILLINOIS COUNCIL OF TEACHERS OF MATHEMATICS

The thirteenth Annual Conference of the Illinois Council of Teachers of Mathematics will be held on the campus of the University of Illinois, Champaign-Urbana on October 13–14, 1961. The Conference begins with a dinner meeting on Friday evening, October 13 with Dr. Eugene Ferguson of Newton High School, Newtonville, Mass., as the principal speaker. He will speak on "New Programs and How Changes Can Be Made in Our Schools." This program should be of interest to administrators as well as teachers of mathematics since the meeting will be concerned with the new programs in mathematics and the problems of administration. Dr. Eugene Ferguson was appointed by the National Council of Teachers of Mathematics to serve as speaker at the eight regional conferences concerned with implementation of current programs in the teaching of experimental programs in mathematics.

On Saturday, October 14, General Sessions on both the secondary and elementary levels will be a panel discussion on the "Experimental Programs in Illinois"—moderated by Dr. Eugene Ferguson (secondary) and Dr. Maurice Hartung (elementary). Panel members will include representatives of the major experimental programs at *all* levels of instruction.

Reservations for the dinner on Friday, October 13 should be sent to Conference Supervisor, Division of the University Extension, 116D Illini Hall, Champaign, Illinois. The price of the dinner is $2.75. A luncheon will be held at noon in the Illini Union Ballroom. The price of the luncheon is $2.00. Reservations should be sent to the same address as indicated above.

FLUORESCENT LIGHT SHOWS FOOD POISONS ARE PRESENT

Some poisons sprayed on foods to combat insect pests can be made to signal their danger by the light they give off when flooded with ultraviolet radiation.

The International Congress of Pure and Applied Chemistry was told that fluorescence measurements have higher sensitivity than other methods, but can be applied only when the chemical itself is fluorescent or can be made to produce a compound that has this effect.

A New Look at $e^{i\theta} = \cos\theta + i\sin\theta$

Henry Albaugh
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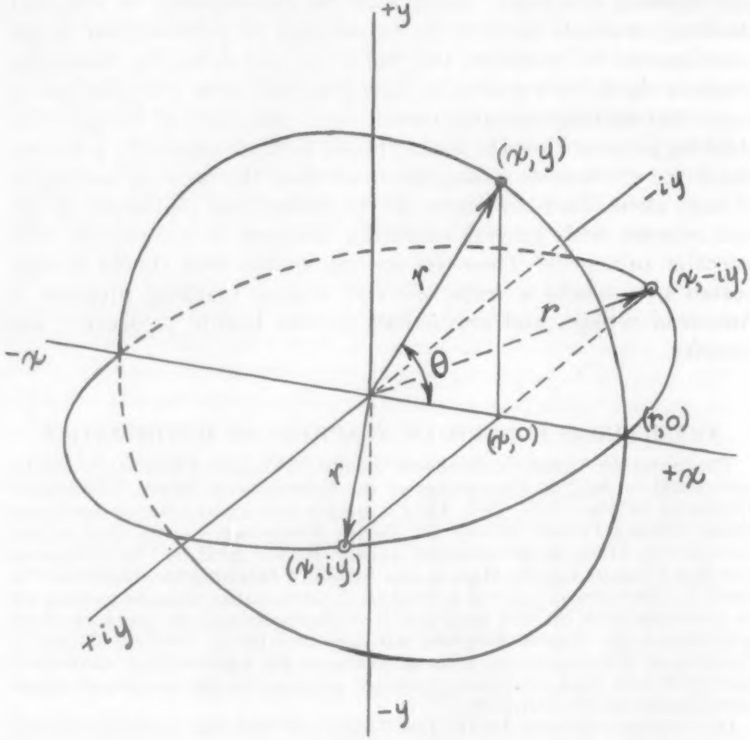
Fig. 1 depicts geometrically the relationships we wish to use.



If the point (x, y) moves about in the real plane along the circle

$$x^2+y^2=r^2, \tag{1}$$

the points $(x, +iy)$ and $(x, -iy)$ will travel along a corresponding circle in the complex plane, since to each point (x_1, y_1) there corresponds the points $(x_1, +iy_1)$ and$(x_1, -iy_1)$. This mapping takes place since upon factoring (1) we obtain the relation

$$x^2+y^2=(x+iy)(x-iy)=r^2 \tag{2}$$

Where

$$i=\sqrt{-1} \tag{3}$$

$$r=|x\pm iy| \tag{4}$$

$$\theta=n\pi=\tan^{-1}y/x \qquad n=\pm 1,\pm 2,\pm 3,\cdots \tag{5}$$

We obtain by differentiation of (5)

$$d\theta=\frac{xdy-ydx}{x^2+y^2} \tag{6}$$

If we factor the denominator of (6) we get

$$d\theta=\frac{xdy-ydx}{(x+iy)(x-iy)} \tag{7}$$

If we multiply both sides of (7) by $2i$ we obtain

$$2id\theta=\frac{2xidy-2iydx}{(x+iy)(x-iy)} \tag{8}$$

The right side of (8) can be written

$$2id\theta=\frac{2xidy}{(x+iy)(x-iy)}-\frac{2iydx}{(x+iy)(x-iy)} \tag{9}$$

In accordance with the method of partial fractions (9) may be expressed in the form

$$2id\theta=\frac{Aidy}{(x+iy)}+\frac{Bidy}{(x-iy)}+\frac{Cdx}{(x+iy)}+\frac{Ddx}{(x-iy)} \tag{10}$$

Thus (10) becomes

$$2id\theta=\frac{idy}{(x+iy)}+\frac{idy}{(x-iy)}+\frac{dx}{(x+iy)}-\frac{dx}{(x-iy)} \quad —$$

Rearranging and combining (11) we have

$$2id\theta=\frac{dx+idy}{(x+iy)}-\frac{dx-idy}{(x-iy)}$$

or

$$2id\theta=\frac{d(x+iy)}{(x+iy)}-\frac{d(x-iy)}{(x-iy)} \tag{12}$$

Hence by integration of (12)

$$\int 2id\theta=\int\frac{d(x+iy)}{(x+iy)}-\int\frac{d(x-iy)}{(x-iy)}$$

or

$$2i\theta = \ln = (x+iy) - \ln (x-iy) + \ln C$$

If

$$\theta = 0, \quad y = 0 \quad \text{then} \quad \ln C = 0$$

Thus

$$i\theta = \ln \left[\frac{(x+iy)}{(x-iy)} \right]^{1/2} \tag{13}$$

If we put (13) in the exponential form we obtain

$$\left(\frac{x+iy}{x-iy} \right)^{1/2} = e^{i\theta} \tag{14}$$

Multiplying numerator and denominator of (14) by the conjugate of the denominator the expression under the radical becomes

$$\left[\frac{(x+iy)^2}{(x-iy)(x+iy)} \right]^{1/2} = e^{i\theta}$$

Since

$$(x-iy)(x+iy) = r^2$$

$$\left[\frac{(x+iy)^2}{r^2} \right]^{1/2} = e^{i\theta} \tag{15}$$

Therefore

$$\frac{(x+iy)}{r} = e^{i\theta} \quad \text{or} \quad x+iy = re^{i\theta} \tag{16}$$

(16) can also be written

$$\frac{x}{r} + \frac{iy}{r} = e^{i\theta} \quad \text{or} \quad \cos \theta + i \sin \theta = e^{i\theta}$$

RADIOACTIVE IODINE PROMISING IN CERTAIN HEART AILMENTS

Using radioactive iodine to slow down the metabolic rate is a promising new method of treating certain types of heart disease.

Patients with severe heart pains (angina pectoris), congestive heart failure and recurring irregular heart rhythms (tachycardia and auricular fibrillation) are given small, harmless doses of radioactive iodine periodically. The iodine is selectively taken up by the thyroid gland, which influences the body's metabolic rate. The iodine's radiation reduces thyroid activity. As a result, metabolism is slowed and the heart's work load markedly decreased.

Of the 202 patients so treated, 167 showed marked improvement. Patients with angina were generally relieved of pain and were able to exercise more freely. Personality improvement was also observed, probably as a result of decreased emotional tension from lower metabolic rate.

A Mathematical Problem with Geographical Constraints

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It is interesting to note how frequently mathematical relationships are overlooked when we are satisfied with an obvious but trivial solution of a problem. It is likewise interesting to note how often nontrivial solutions are more revealing than trivial ones and how often our very failure to *try deliberately* to generalize, *if possible*, the conditions which held for the trivial solution, results in overlooking whole classes of relationships and problems which have not been investigated and which are distinctly worthwhile exploring. It is my intention to present here a problem of the type mentioned.

In dealing with this problem we do not pretend that we have made use of the fullest possible rigor or that we have employed the optimal systematic presentation. We are interested chiefly in the logical relationships involved. The reasons for this are threefold: (1) we wish to point out how a given method of learning mathematical relationships *may* blind us psychologically to the existence of other relationships similar to or derivable from the given method: (2) pedagogically it is more important that the reader *see the problem* regardless of whether or not it has been presented with maximum rigor and elegance, for often a compressed, mathematical presentation may deprive him of the ability to see the interesting relationships in another context; and (3) we wish to bring this problem to the attention of geographers and students of navigation, as well as mathematicians, and geography and navigation constitute two examples of what we mean by other contexts. This explanation, then, provides the justification for the approach we have employed.

Teachers of geography and mathematics may find it both interesting and instructive to present the problem which will be described below to their students. From the standpoint of geographic interest, the problem will bring out the precision or ambiguity with which such concepts as latitude and longitude are held; the clarity with which ideas governing conventional meanings of direction have been absorbed, when involving areas that are not plane surfaces; and the degree to which living north of the equator, as well as the familiar orientation of maps with the North Polar region toward the top, tend to create erroneous geographical judgment. From the standpoint of mathematical interest, the problem to be discussed brings out rather well the blockages to problem solving created by what the psychologist calls *rigidity of mental set*.

The problem, itself, arises out of one which psychologists are fond of using and which laymen treat as a standard brain-teaser. The

problem takes many forms, but its most familiar setting is the following:

> A man is standing at a point, P, somewhere on the earth's surface. He then walks due South 10 miles, due East 10 miles, and due North 10 miles and finds himself back at point, P. Where is he?

The standard answer, of course, is "the North Pole." Sometimes the word "animal" is substituted for "man," the word "it" for "he," and the word "itself" for "himself," and the respondent is asked to identify the animal and/or name its color. In this case the correct answers are, of course, "polar bear" and "white," respectively.

It is curious that from a mathematical as well as a geographical standpoint, most intelligent respondents, including some sophisticated college professors, will insist that the North Polar point is the only point which correctly satisfies the conditions of the problem. This is frequently true even when the respondents are told specifically that there are loci containing an infinite set of points, each of which satisfies the mathematical and geographical constraints of the problem. They balk even more when they are told that, furthermore, there is an infinite set of such loci, each of which contains an infinite set of points satisfying the conditions of the problem. The discussion below is intended to show that this is so.

Consider a circle of latitude, A, in the neighborhood of the South Pole, which possesses a circumference of 10 miles. Now consider another circle of latitude, A', which is 10 miles due North of A, and whose projection on the horizontal plane in which A lies would be concentric with A. Take any point, P_1', of A' and apply the constraints of the problem already mentioned. If a subject were to walk 10 miles due South of P_1', he would land on some point, P_1, on A. If he now moved 10 miles due East, he would circumnavigate the globe via the circle, A, and return to P_1. If he then walked due North 10 miles he would arrive back at P_1', of A. This route satisfies the conditions of our problem. But P_1', is *any point* of circle, A'. Therefore, *every point* of A' satisfies the conditions of our problem, and A', of course, contains an infinite number of points.

In this connection, it is to be noted that walking due East is called for in a mathematical context only, in which it is assumed that the subject knows only the direction of the North Pole. If he then faces the North Polar point, due East would have to be the direction on his right, so that his route along A would have to be counterclockwise with reference to the North Pole, as he, himself, would describe it. This is because the earth rotates from West to East if one faces the fixed polar point and, since the direction of the rising sun, which is defined as being East, is a function of this rotation, East would

then be on our subject's right and his route of travel would be given by a directed line running from his left to right.

A', however, is only one such locus which satisfies the conditions of our problem. Let us speak of A' and A as *geographically conjugate.* Two circles of latitude will be said to be geographically conjugate if they satisfy the conditions of our problem. It has been previously implied that there is an infinite set of such loci, each of which has its geographical conjugate. Let us designate B' as *any other member* of this set which, like A', has its geographical conjugate, B. What are the characteristics of B? B is a circle of latitude whose circumference is n, where the mathematical constraint, $10/n=Q$, holds; and where $n \leq 10$ and such that Q will be an integer. Under these constraints, B too will satisfy the conditions of our problem. In this case the subject merely circumnavigates the globe Q times via B, traveling in a due East direction, and will always come back to a point, P_2, on B from which he had started to travel due East. Such a point, P_2, is conjugate to a point, P_2', on a circle of latitude, B', which is 10 miles due North of B, and whose projection on the horizontal plane in which B lies is concentric to B. Thus, for this situation, the subject has started from P_2', walked due South to P_2, and then circumnavigated B a total of Q times. After the Qth circumnavigation, he finds himself at P_2 once more, walks due North 10 miles, and arrives at P_2', on B', which was his starting place. Therefore, this route satisfies the conditions of our problem. But B' is, by definition, *any other member* of an *infinite set* of loci, each of which possesses a geographical conjugate. It should be noted that, under these circumstances, there are an infinite number of *pairs* of circles of latitude which are geographically conjugate. For each such pair the more northerly circle of latitude contains an infinite set of points which satisfy the conditions of the problem.

Thus far, it is clear that there are two classes of solution to our original problem. These are: (1) the *singular point* represented by the North Pole, and (2) any point in any one of the infinite set of loci, such as A'. Points in these two classes depend on a path defined by *motion of translation* for the subject. There is, however, one other class of solutions, namely, a locus containing an infinite set of points, each of which will satisfy the conditions of our problem but which depends upon using *motion of rotation* as an admissible means of movement by the subject. This latter class of solutions is given as follows. Take a circle of latitude, C', such that it is 10 miles due North of the South Polar point. Select any point, P_3', on C'. If a subject walks due South 10 miles, he will arrive at the South Pole. If he is now allowed to turn clockwise, using the South Polar point as a pivot, that is, from his left to his right, his rotation will match directionally

the previous motions of translation. If we measure motion of rotation by the distance covered by a fixed, imaginary point, P_3, on, say, the subject's right arm, then this point will turn in a circle of circumference, c, in a plane parallel to existing circles of latitude. After m such rotations, where $mc=10$ miles, the subject stops, walks due North 10 miles until he arrives again at P_3'.[1] This situation also satisfies the conditions of our original problem. Since, however, P_3' is *any point* of the locus, C', this demonstrates that there is a third class of solutions involving an infinite number of points.

It is appropriate at this point to generalize some of the foregoing observations. The first matter to be noted is that the standard value for distance, d, namely 10 miles, is arbitrary. Whether or not we take cognizance of the fact that the earth is not a true sphere (by including or neglecting the actual flattening at the polar regions and the bulging at the equatorial regions), if we assume that the path of arc due South of the North Pole possesses any length, d, and the circumference of the circle of latitude to be circumnavigated from West to East is n, then the general conditions of our problem can be satisfied regardless of whether $d \lesseqgtr n$. If $d<n$, the path taken will be one of a class of spherical triangles, each possessing one vertex at the North Pole. If $d=n$, the path will be one which consists of a spherical arc from the North Polar point to a circle of latitude, followed by a single West to East circumnavigation of this circle, followed by a return route to the Pole along the original spherical arc.[2] If $d>n$, the path taken will be one of an infinite possible number, each of which consists of a spherical arc from the North Polar point to a circle of latitude, followed by the circumnavigation of this circle more than one complete time, followed by a return route to the Pole either along the original or a second spherical arc of length, d.[3] Thus, the North Polar point will satisfy the conditions of our problem whenever $O<d\leq C/2$, where C is the circumference of the earth, and motion of rotation is admissible.

For all of the preceding generalized conditions, the *singular solution* is the North Polar point. Generalized *non-singular solutions* to the problem are also possible, and these, unlike previous examples of non-singular solutions, do not have to involve conjugate loci both of which are either above or below the equator. Consider a circle of circumference, D', somewhere between the North Pole and the equator. Let d be the distance of a path of arc, beginning at any point on D' and

[1] Note that if m is not an integer, the subject will return to C' but not P_3', thus failing to achieve a solution.

[2] For this case to be true, one would have to establish the *existence theorem* that, somewhere *south of the Equator only*, there is *at least one* circle of latitude, X, whose circumference is equal to the length of arc, d, from the North Pole to the circle, X. Once done, X is located by *approximation methods only*.

[3] For this case to be true for a return along the original arc, one would have to establish an *existence theorem* proving that there is *at least one* circle of latitude, Y, whose circumference, n, is such that the length of arc, d, is a multiple of n and that Y is somewhere below the equator.

ending somewhere below the equator. Then some circle of latitude, D, below the equator, such that the length of arc, d, is a multiple of the circumference, n, of the circle, D, will satisfy the conditions of our problem. Such a conjugate locus can always be found which will satisfy the constraints that $d/n=Q$, where Q is an integer. This can always be done by selecting a circle, D, below the equator, possessing circumference, n, then describing a longitudinal arc of length, Qn, which will pass above the equator, and then drawing D' so as to abut the terminus of this spherical arc.

We thus see that there are three separate domains in which geographical conjugates may be found: (1) between the North Pole and the equator, and including the latter, in which domain the North Polar point is, in effect, a singular conjugate of every other parallel on the earth's surface in this domain, being equivalent to a circle of latitude with zero radius; (2) between the equator and the South Polar point, and including both of these if motion of rotation is admissible at the South Pole; and (3) between the North and the South Poles, and including these if motion of rotation is admissible at the South Pole. These three separate domains, however, are only the artifacts of our analysis. If we forget these artifacts, we can legitimately claim that *any point on the earth's surface* is capable of satisfying the conditions of our problem, providing an appropriate specific value of d is selected.

Are there, then, classes of paired circles of latitude which *cannot* be geographical conjugates satisfying the conditions of our problem? The answer is clearly in the affirmative. Non-permissible paths will be found in each of our three artifactual domains. In each domain, a condition for a path to be non-permissible is clearly when the value of d, a path of arc between D' and D, where D' is the more northerly circle of latitude, is such that the governing constraint, $d/n=Q$, is not satisfied because $d<n$. Obviously, there is an infinite set of such geographical non-conjugates, D' and D, where each D' contains an infinite set of points which will not satisfy the conditions of our problem.

The upshot of all our preceding analysis, then, is this. Any given point on the earth's surface *may or may not* satisfy the conditions of our problem, depending upon the relation between d and n in the governing equation, $d/n=Q$. For all interpolar values of d where $d<C/2$, one half the circumference of the earth, where $n\leq d$, and where Q is an integer, points can always be found to satisfy the given conditions. All values of d such that Q is not an integer, that is, $d<n$, and all values of n where $n<d$ but d/n does not yield an integral quotient, define non-permissible paths.

It may therefore be seen that the standard solution to our problem,

namely, the North Polar point, is only one class of correct solutions involving a *singular point*, and that furthermore this solution is probably the least interesting one of all the several classes of possible solutions. These solutions are all proposed in a mathematical sense so that the practical requirements of effecting them geographically, involving astronomical considerations and navigational devices, are not at issue. The problem herein considered is elaborated upon because it is uncommon to find respondents who will notice any solution other than the singular, North Polar point, and because this inability, whether posed in a geographical or a mathematical context, illustrates so interestingly and strikingly what the psychologist calls *rigidity of mental set*.

A SEMINAR AND FIELD STUDY IN EUROPE
REFORMS AND POLICY-MAKING IN EUROPEAN EDUCATION

NOVEMBER 11–28, 1961
Planned for School and University Board Members and Administrators
Under the Combined Auspices of:
The National School Boards Association
The International Commission of Phi Delta Kappa
The Comparative Education Society

The Comparative Education Society and the Commission on International education of Phi Delta Kappa have sponsored many seminars and field studies on education in foreign lands. These have been intensive first-hand studies of education institutions as they operate in their cultural settings. As such, they have been designed primarily for professors of education.

Because of the widespread interest in European education and the many current references to it in the popular press of the United States, the three national organizations believe that school and university administrators and their lay boards could benefit from a series of seminars designed specifically for them. The time of the year best suited for this is thought to be the month of November when administrators can be free from their professional duties.

An especially attractive excursion plane fare together with the cooperation of educational officials and professors in each of the countries to be visited make this a very low-cost undertaking. Ordinarily the New York to Moscow flight is $800. The total cost of the seminar is $1,000.

The cost of the seminars, school visits, and other featured events will be $1,000, New York to Moscow and return to New York. This includes trans-Atlantic transportation of jet economy class, tourist flights throughout Europe, transfers to and from airports, airport taxies, basic tips, twin-bedded rooms wherever possible with bath, and other scheduled events. The group will no doubt be hosted frequently along the way. All meals will be provided in Moscow but only breakfasts in other countries. Twnety-five dollars should cover the cost of meals. Each person must pay his own passport and visa fees if any be required. Those desiring to remain in Europe for a longer period may do so for an additional ticketing cost. Stop-overs in Warsaw, Prague, Zurich, and other cities may be planned.

Participation is open to anyone interested in reforms and administration of European schools. Those who are actively engaged in education as a profession may claim a deduction of their expenses for income tax purposes. Husbands and wives may accompany each other.

All inquiries and requests for application forms should be sent to Dr. Gerald Read, Secretary-Treasurer, Comparative Education Society, Kent State University, Kent, Ohio.

The Problem-Solving Approach—Fact or Fancy?

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No academic course in the high school or junior high school is better suited to the problem-solving technique of teaching than is science. Yet, one of the criticisms most frequently heard about science teaching is that problem-solving is not a vital part of the science program. Critics claim that the usual science class takes the form of a read-question-answer session. Students are given the answer by the textbook or by the teacher and are asked to memorize and recall this answer. Opportunities for students to discover answers on their own, we are told, are very limited.

The question which should concern all science teachers is, "How valid are these criticisms? To what extent *is* problem-solving a real part of our program?"

The answers to these and similar questions are, unfortunately, difficult to discover. Theoretically, it would be desirable to go into science classrooms all over the United States and find out just what and how science teachers are teaching. Obviously, this method is completely impractical, and some other means must be used to determine the validity of the above criticisms.

One possible practical solution to this problem is to conduct a survey of teacher-made tests. This approach is predicated on the theory that, basically, the tests which a teacher gives reflect the general educational philosophy of the teacher. One would expect that the teacher who uses problem-solving in his classroom lessons would also use problem-solving in his tests. It would be somewhat inconsistent to expect a teacher to inculcate the problem-solving approach in the classroom, to give students actual problems to solve, to encourage analytical thinking during daily lessons—and then to administer a straight fact test at the end of a unit. Thus, this writer bases the present research work on the hypothesis that an evaluation of the character of science tests will give a reasonably accurate estimate of the nature of the science teaching which is now occurring.

Method

The survey which is summarized below was conducted in December of 1960. The goal of the study was to discover the general nature of teacher-made science tests in junior high school general science. Letters were sent to 66 public school systems in 50 states requesting the following materials: (1) one copy of a junior high general science teacher's best test, (2) one copy of the same teacher's most recent

test, and (3) one copy of the teacher's typical test. Replies were received from 17 schools in 15 geographically distributed states. These replies included 112 different test samples. However, since some respondents included more than one test of each kind, only 57 tests were actually tabulated.*

In all, 1906 separate questions were read, evaluated, and tabulated. Each of these questions was analyzed in two different ways. First, the question was categorized as "factual" or "reasoning" according to the following scheme:

Class I: Those questions requiring an answer which is a statement of a principle or the statement of some factual information. Answers to these questions would have been memorized from some previous classroom or textbook experience and then repeated by the student on the test.

Class II: Those questions which require an answer arising from the application of some principle or from a process of reasoning. These are questions which, presumably, are completely new to the student. They would require enough original thinking on the part of the student to permit him to "figure out" the answer.

Secondly, the question was classified within one of the traditional categories as being true-false, completion, multiple choice, etc. The results of this analysis are summarized in table 1.

The actual figures which appear in table 1 might be misleading since they do not necessarily indicate the relative values of the various questions. That is, according to this tabulation, one essay question (which might require an answer a paragraph in length) is equated to one one-word completion question or one true-false question. Table 2 presents a somewhat more realistic view of the relative values of the questions. In this table, each question has been "weighted" by giving it a point value approximately equal to the number of words in the answer. Thus, a true-false question would be tabulated as 1, while a statement of a principle might be tabulated as 6.

In order to provide a basis for comparison, a group of ten textbook company tests were also surveyed in the same fashion as were the teacher-made tests. The results of this second part of the survey are shown in table 3.

Conclusions

The conclusions from the three preceding tables are evident. Both teacher prepared tests and published tests rely very heavily on straight factual, memorization-type questions (note that the weighting proc-

* It shoud also be noted here that the "best" tests received were not included in the tabulation. It was recognized at the outset of the study, as many respondents also indicated, that it is difficult to select a "best" test. Nonetheless, it was felt that the respondents should have the opportunity of providing this material if they so desired. In general, there seemed to be very little difference between the "best" tests and the typical and most recent tests.

TABLE 1

Rank	Type of question	Class I Number	Class I Percent	Class II Number	Class II Percent
1	Completion	467	24.5%	44	2.3%
2	Matching	327	17.2%	0	0.0%
3	True-false	239	12.5%	30	1.5%
4	Listing and/or stating (Any question which requires a list of properties, steps, etc., or which requires a single word or brief phrase as an answer)	188	10.0%	1	0.0%
5	Multiple choice	154	8.1%	17	0.9%
6	Drawing and/or labeling of diagrams	114	6.0%	7	0.3%
7	Definition	90	4.7%	0	0.0%
8	Problems (mathematical)	52	2.7%	0	0.0%
9	Less than 50 questons: Miscellaneous (includes "compare and contrast," "tell all you know," etc.), 42, 2.2%, 21, 1.1%; discussion, explanation evaluation, (any question requiring an answer of at least one full sentence), 28, 1.4%, 19, 1.0%; modified true-false, 23, 1.2%, 16, 0.8%; chemical equations, 11, 0.5%, 1, 0.0%; "Which term does not belong," 0, 0.0%, 15, 0.7%.				
	Total	1735	91.0%	171	9.0%

TABLE 2*

Rank	Type of question	Class I Number	Class I Percent	Class II Number	Class II Percent
1	Discussion, explanation, evaluation	654	14.8%	324	7.3%
2	Definition	540	12.3%	0	0.0%
3	Listing and/or stating	508	11.5%	1	0.0%
4	Completion	467	10.6%	120	2.7%
5	Matching	327	7.4%	0	0.0%
6	Problems (mathematical)	274	6.2%	0	0.0%
7	True-false	239	5.4%	30	0.7%
8	Miscellaneous	215	4.8%	187	4.2%
9	Drawing and/or labeling of diagrams	216	4.8%	12	0.3%
10	Multiple choice	154	3.5%	17	0.4%
	Less than 100: chemical equations, 66, 1.4%, 6, 0.1%; modified true-false, 23, 0.5%, 16, 0.4%; "Which term does not belong," 0, 0.0%, 15, 0.3%.				
	Total	3683	83.5%	728	16.5%

* Weighted on the following basis: one word or short phrase answer = 1; sentence, mathematical problem, or chemical equation = 6; paragraph answer, from 12 to 36.

TABLE 3

Rank	Type of question	Class I		Class II		Class III*	
		Number	Percent	Number	Percent	Number	Percent
1	Multiple choice	234	43.6%	20	4.0%	13	2.4%
2	Completion	177	33.0%	5	0.9%	5	0.9%
3	Discussion, explanation, evaluation	34	6.3%	0	0.0%	0	0.0%
4	True-false	23	4.3%	2	0.3%	0	0.0%
	Less than 20 questions: Matching, 14, 2.6%; 0, 0.0%, 0, 0.0%; drawing and/or labeling of diagrams, 7, 13.%, 1, 0.2%, 0, 0.0%; miscellaneous, 1, 0.2%, 0, 0.0%, 0, 0.0%.						
	Total	490	91.4%	28	5.3%	18	3.3%

* These questions are applications of principles or reasoning questions (like those listed under Class II) except that the specific example mentioned in the question had already been discussed in the textbook. Thus, the factors of retention and recall rather than of reasoning are involved.

ess used in table 2 does not greatly alter the results). Less than one-fifth of the questions reviewed could conceivably be classed as "thought" questions. If the initial hypothesis is accepted—if one believes that a test reflects a teaching philosophy—then it becomes quite obvious that problem-solving is more myth than fashion in current junior high teaching.

It should be pointed out that some of the respondents were aware of this "deficiency" in the products which they returned. Their justifications for so few "essay" questions or "reasoning" questions was that they lacked time to correct such tests. This certainly is a legitimate complaint. However, it might be more constructive for teachers to complain about their lack of time for *preparing* such tests, for it became obvious during the course of the study that thought questions need *not* be long essay questions. Short answer questions can be prepared which require reasoning in their answers. The problem is that such questions are not readily available and, hence, do require time for composition. Further progress in the use of problem-solving in science education, then, might take the direction of providing more objective tests requiring reasoning and critical thinking. When these are available, the goal of a problem-solving course in science can become more nearly a reality in every class.

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A Review of Research Dealing with Current Issues in Mathematics Education

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Introduction

It is the purpose of this paper to review research dealing with current thinking concerning important issues in the field of mathematics education. The studies presented herein have been completed during the last three years, many being products of national groups assembled in an attempt to resolve pertinent questions that have arisen in mathematics education. The three topics of major concern will be (1) a program for the academic preparation of high-school mathematics teachers, (2) a revised program for college-preparatory mathematics, and (3) certification requirements and qualifications of mathematics teachers. Research concerning topics (1) and (2) will deal only with the materials that should be included in these programs. Data will not be presented with respect to how effective or realistic the proposed programs are. The data were gathered through a search of the journals found in the Western Michigan University Library, and the studies have been arbitrarily categorized under three main headings.

Findings

What academic courses should be included in a program of teacher education at the undergraduate level for high-school mathematics? The Committee on the Undergraduate Program in Mathematics of the Mathematical Association of America (11) has recently appointed a panel of experts to prepare recommendations for standards for the training of high-school mathematics teachers. The following data have been endorsed by both the committee previously mentioned and the Board of Governors of the Mathematical Association of America.

The recommendations indicate that the minimal requirements for teachers of high-school mathematics should include (1) nine semester hours in the area of analysis, consisting of three hours in analytic geometry and six hours in calculus; (2) six semester hours in abstract algebra, with three hours constituting an introduction to the structure of algebra, i.e., groups, fields, rings, etc., and the remainder consisting of topics from linear algebra; (3) six semester hours in geometry beyond analytic geometry, including topics in geometric foundations, notions of congruence, measure theory, or a "purely analytic" treatment of geometry; (4) six semester hours in the area of probability

and statistics with the theory of probability treated from a set-theoretic viewpoint stressing the application of probability to statistical problems; and (5) six semester hours of advanced electives, e.g., theory of numbers, an introductory study of real variables, history of mathematics, topology and numerical analysis (computers). One of the above areas should include introductory set theory and logic, useful in many of the areas of mathematics.

The total program consists of approximately 33 semester hours in mathematics and it is emphasized that these represent the minimal requirements for the academic preparation for prospective high-school teachers.

The following data were compiled from the 1959 report of the Sub-Committee on Teacher Certification—the Cooperative Committee on the Teaching of Science and Mathematics of the American Association for the Advancement of Science, Alfred B. Garrett, chairman (6). The purpose of this report was to make recommendations for teacher preparation in the areas of science and mathematics. This paper deals with part five of the report, "Suggested Courses in Mathematics and Science for High-School Teachers of Mathematics."

It was stated in the report that the members of the committee believed approximately 50% of the time spent in course work at the undergraduate level should be devoted to preparation in the subject-matter area.

The number of semester hours for each of the suggested courses are, as before, the minimal requirements for undergraduate mathematics preparation. Since most areas in the following courses have been defined in the previous study, only those not previously discussed will be elaborated upon at this time. It is the consensus of opinion of the committee that there should be 12 hours of analysis and three hours each of probability and statistics, abstract algebra and geometry. The remaining nine hours of the recommended 30 consist of six hours in applied mathematics, including the areas of mechanics, numerical analysis, and linear programming, and three semester hours entitled "Foundations of Mathematics." The last category consists of set theory, the real number system, the complex number system, postulates concerning arithmetic, algebra and geometry, and symbolic or mathematical logic.

The report also indicated that the prospective teacher of high-school mathematics should have 18 semester hours in a supporting science chosen from courses in physics, chemistry, astronomy, biology, meteorology and geology.

Brown (2), who has compiled a report of the mathematics section of the Midwest Regional State College Conference on Science and Mathematics Teacher Education states, based on the findings of the

conference, that the prospective mathematics teacher should come in contact with at least three of the four main branches of mathematics, namely analysis, abstract algebra, probability and statistics and geometry.

The findings of this conference indicate that the first two years of college mathematics should be spent in background courses in analytic geometry and calculus. The junior and senior years should include topics beyond calculus, with students enrolling in three-hour courses in "Mathematical Systems," e.g., axiomatics or logic, the real number system, abstract algebra, and axiomatic geometry. Additional semester hours to total six are elected from topics in applied mathematics, geometry, advanced calculus, and more advanced algebra courses.

Brown (3) has also compiled the reports of the mathematics sections of the AAAS Mideast Regional State College Conference on Science and Mathematics Teacher Education.

The discussion groups recommended that the prospective high-school mathematics teacher should have completed, by the end of his sophomore year, at least 12 semester hours in college mathematics courses. This work should include six hours of calculus.

During the last two years a major in mathematics should be completed consisting of 30 hours, although 36 is the preferred number. A total of 15 hours should be taken from the following five areas, (1) analysis, (2) abstract algebra, (3) the foundations of mathematics, including logic, (4) probability and statistics, and (5) geometry. There should also be six semester hours of work in a related field.

Leissa and Fisher (8) in a survey of opinions of 280 mathematics teachers concerning the high-school mathematics curriculum, included in a questionnaire an item inviting each respondent to indicate the minimal number of quarter hours of college mathematics of calculus and beyond needed to teach the "modern" program of mathematics infiltrating the traditional approach. About 75% of the 186 responses indicated that at least 40 quarter hours should be included in the undergraduate program.

In summarizing this section the reviewer should state that since four of the five studies cited above are reports, no mention is made of the method of collection of data. The reviewer suggests that the "jury-technique" was probably used, as in each situation a group of experts in the field of mathematics education are expressing their opinions.

The findings of each study are in almost complete agreement as to the academic subjects to be included in the teacher-education program as well as the total number of hours in mathematics to be included. There is some variation in the breakdown of hours for each

course, but the data indicate no important differences.

What topics should be included in a revised college-preparatory mathematics curriculum for grades 9–12? As a result of a questionnaire-study (9) conducted in March, 1958, the N. E. A. Research Division found that curriculum revision in high-school mathematics was on the increase. In the two years prior to the study 43% of the schools indicated they had completed a curriculum revision in mathematics. Over 50% stated they had new programs in progress. It was also found that about 33% of the schools were revising their mathematics curricula so as to include new courses emphasizing the modern viewpoint.

Since this study indicates that much revision is going on in the nation's high schools, it is desirable to determine what a four-year program of college-preparatory mathematics should include.

The following is a report by Meder (10) of a proposed four-year mathematics program for the college-capable high school student, set forth by the Commission on Mathematics of the College Entrance Examination Board.

The members of the Commission recommend that the first- and second-year algebra courses be taught from the modern viewpoint. There should be emphasis on mathematical structure and deductive reasoning with the concepts of sets, relations, functions, inequalities, and absolute value included along with traditional topics.

There should be a course in geometry emphasizing deductive reasoning, with the present list of required theorems being greatly reduced. There should be included an introduction to algebraic methods as applied to geometry, with the final recommendation being that solid geometry be included in this course and eliminated as a separate subject.

The Commission also recommends that the present trigonometry course be divided into three sections. Some topics should be eliminated while angle trigonometry along with topics of a computational nature which are to be retained should be presented as a part of the second-year algebra course. "Analytic trigonometry" should be included in the fourth-year course.

These courses pave the way for the final year of high-school mathematics which the Commission proposes should be made up of two parts. The first semester could be entitled "Elementary Functions," with the student studying polynomials, exponential, logarithmic, and trignometric functions. The second semester should consist either of a course in probability and statistical inference or an introduction to abstract algebra. It is not the recommendation of the Commission that calculus be a part of the high-school mathematics curriculum.

The members of the Secondary-School Curriculum Committee of

the National Council of Teachers of Mathematics (14) have attempted to answer the question, "Which of the conventional topics of mathematics, if any, should be radically changed or eliminated?" Their report recommends that a ninth-grade course consist of modern elementary algebra, including set theory and inequalities. There should be a geometry course in the 10th grade that emphasizes synthetic methods. This course should include the essentials of solid geometry as the members of the committee believe that "it is neither necessary nor desirable to devote a full semester to deductive solid geometry."

Grade 11 should include the topics of advanced algebra and trigonometry, with the program in grade 12 consisting of any two of the following, (1) probability and statistics, (2) analytic geometry, or (3) mathematical analysis based on the study of elementary functions.

This report also states that some schools might find it desirable to offer a course in analytic geometry and calculus for senior mathematics students.

In an attempt to determine if college and high-school teachers differ as to whether the high-school mathematics curriculum should be revised, Leissa and Fisher (8) disseminated a 15-item questionnaire to approximately 280 mathematics teachers attending the Third Annual Symposium of Engineering Mathematics held in May, 1959 at Ohio State University.

Of the 186 questionnaires returned 132 were from high-school mathematics teachers or supervisors. The data from both groups indicated strong support for revision. Topics to be included in the revised Curriculum were inequalities, absolute values, algebra of sets, limit concepts, vectors, determinants and probability and statistics, while calculus, group theory and fiēld theory should be left to the colleges.

The data indicated conclusively that the teachers who responded were in agreement that there shold be a revision of the high-school mathematics curriculum, the only importat difference being that the high-school teachers believed the traditional curriculum should be more extensively revised than did the college teachers.

Brant (1) conducted a survey to determine if solid geometry is a requirement for entrance to engineering schools, and, if so, whether the schools that require solid geometry will accept a "fused" course of solid and plane geometry. This question is pertinent in view of previously stated studies indicating the elimination of solid geometry as a separate course.

Brant cites a study by Keedy (7) of the University of Maryland, who contacted 147 engineering schools offering an engineering degree and accredited by the Engineers Council for Professional Develop-

ment, to determine if solid geometry was a requirement for entrance. Of the total, 96 indicated that solid geometry was no longer a requirement.

As a result of Keedy's findings, Brant surveyed 50 of the 51 schools requiring solid geometry to determine if the one-year integrated geometry course would be a suitable replacement.

The data indicate that the number now requiring solid geometry has now been reduced to 23. It was also found that of the 50 schools, 38 stated they would accept the fused course, and 134 of the total stated they would accept credit in the one-year integrated course.

Brant concludes, therefore, that the trend is toward the fusion of plane and solid geometry into one course, both from the point of view of the curriculum planner in the high school, and entrance requirements in engineering colleges.

"If solid geometry is to be taught with plane geometry rather than as a separate subject, what topics should be retained?" In an attempt to answer this question, Small (13) formulated a questionnaire listing topics compiled from six leading texts in solid geometry presently in use in the nation's schools. The criterion for inclusion of a topic was its appearance in a minimum of three texts, and the final list consisted of 109 items. The questionnaire was disseminated to 40 carefully selected college and secondary mathematics teachers. Each respondent was invited to check each item as to whether it should be formally proved, informally proved, merely postulated, or omitted.

There were 36 questionnaires returned of which 31 were usable. The results were tabulated and a 50% level for complete rejection of an item was chosen. Of the total, 14 items were rejected or omitted including the topics of congruence of prisms, spherical triangles and volume of prismatoids. The level of acceptance for including a topic was 75% and there were 58 items chosen by 75% of the respondents.

Small concludes, on the basis of his data, that although the trend is toward elimination of solid geometry as a separate subject, some mathematics educators are reluctant to eliminate this course from the mathematics curriculum in the secondary school.

There seems to be almost complete agreement among authorities that the revised curriculum should include topics in modern mathematics, and that solid geometry should be combined with plane geometry in a one-year course, leaving the 12th year for more advanced courses.

What are the minimal certification requirements for mathematics teachers, and what are the qualifications of the mathematics teachers presently in the field? In an attempt to determine the minimal semester hours in mathematics needed for certification in the various states, Sarner and Frymier (12) requested a statement from each of

the state departments of education concerning their certification requirements for teachers of secondary mathematics.

Replies were received from 40 states and the information concerning the others was gathered from a 1957 University of Chicago bulletin.

The results indicated that 42 states required a baccalaureate degree, with one state requiring an additional one year of college training. The remaining states demanded a lesser amount of training The semester hours of mathematics required for certification at the secondary level ranged from 0 to 24 hours, the mode being 18 hours and the mean 15.1 hours. With the exception of one state, no mention was made of minimal grade requirements.

In a study by Brown and Obourn (4), the qualifications of 799 mathematics teachers in the states of Maryland, New Jersey, and Virginia were secured by an examination of their transcripts. If transcripts were not available the data were secured by direct contact with the teacher.

The findings indicate that 7.1% of these teachers have no preparation in college mathematics, but for the most part the course usually taught by these teachers was general mathematics.

The average number of semester hours in mathematics for teachers in the high-school mathematics curriculum ranged from 17 to 23. It was found that only 61% of the mathematics teachers had taken courses in calculus or beyond. The data also revealed that only 20% of these teachers had taken calculus or any more advanced course since 1950.

Burger (5) has recently concluded a study of the academic preparation of public high-school mathematics teachers in the state of Kansas for the year 1957–58. The data were obtained through examination of the official records of 1,037 mathematics teachers.

The results indicate that approximately 33% of these teachers majored in mathematics receiving at least 24 hours in college mathematics. Over 50% of these high-school mathematics teachers had less than 21 hours of preparation. Only 42% of the total had completed calculus, and 28% had taken over 28 semester hours of college mathematics.

Summary

The reviewer first made an attempt to determine the academic preparation necessary to teach high-school mathematics. Next, the courses to be included in a revised mathematics curriculum in the high school were discussed. Finally, it was found that the certification requirements set up by the various states and the qualifications of teachers presently in the field were much below the desired mini-

mum to teach the revised high-school mathematics curriculum proposed by authorities in the field. It is the opinion of this reviewer that the states must raise their standards for certification of new mathematics teachers, as well as requiring their present staff members who do not measure up to the prescribed amount of preparation to "modernize" their academic backgrounds through in-service education programs. These steps must be taken if the proposed revised high-school mathematics curriculum is to become a reality. It is also the reviewer's opinion that future research efforts in this area be conducted to determine how well the proposed requirements and recommendations really work.

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A PILOT INFORMATION SERVICE OF EDUCATIONAL RESEARCH MATERIAL

I. *Introduction*

The Center for Documentation and Communication Research is conducting a one year pilot study to develop an information retrieval system for educational research material. Work was begun in April on the detailed analysis of over 4,000 documents of current and recent research in educations.

The index style abstract and the semantic code used to prepare technical information for machine storage and retrieval are being adapted to education literature. As of September 1, over 1,400 documents will have been abstracted, including articles from professional journals (over 100 are being scanned), books, dissertation abstracts, literature from branches of the NEA and reports and monographs of the Office of Education cooperative research projects.

Sample questions to be used in the pilot program were solicited through an announcement placed in numerous professional journals. The announcement was also sent to individuals in education, business, and government. Responses have provided more than 200 different questions representing a great many aspects of education and a broad range of specificity-generality.

II. *Scope*

The Center for Documentation and Communication Research is including the following in the input to the system:

1. Sixty-six pamphlets covering various subject areas in education.
2. Office of Education publications, e.g., "Newer Dimensions in Higher Education," "Cooperative Research Monographs," bulletins, and circulars.
3. Dissertation Abstracts, from "Education," August 1960 to present.
4. Books as follows (as of August 10, 1961):

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Taylor, Calvin W., ed. *Third (1959) Research Conference on the Identification of Creative Scientific Talent*. Salt Lake City, University of Utah Press, 1960, 334 pp.
Terauds, Anita, Irwin Altman, & Joseph E. McGrath. *A Bibliography of Small Group Research*. Arlington, Va., Human Sciences Research, Inc., April 1960, (Contract no. AF 49(638)-256, Air Force Office of Scientific Research), 220 pp.
Trabue, Dean M. R. & C. R. Carpenter. *A Bibliography of Production Utilization and Research on Instructional Films*. Port Washington, New York, Special Devices Center, Office of Naval Research, Department of Navy, November 1953, (Tech. Report—Specdevcen 269-7-40), 145 pp.
U. S. Children's Bureau. *Research Relating to Mentally Retarded Children*. Washington, D. C. 1960, (Research Relating to Special Groups of Children, No. 1), 92 pp.

A complete list of journals being abstracted is undergoing revision at present, and will be added to the above in the near future. Some of the questions that have been submitted recently for the fields of science and mathematics are the following:

Teaching of mathematical logic to elementary school children
A comparative evaluation of the major proposal for the teaching of modern mathematics
Learning problems for poor students in 7th and 8th grade arithmetic
Success of able students taking algebra in 8th grade—in algebra and later math courses
Teaching mathematics to bright students
Science education in grades 1–6
Curricular changes in college chemistry teaching
Programs supported by private organizations for college teaching of physical sciences
Programs of independent study in science
Pretesting to determine future success of college chemistry students
Programs for high-ability high school students in science
Use of hand-sorted punched cards in training of college students in chemistry
Use of ETV in the teaching of chemistry to high school and college students
Changes being proposed for training of elementary and high school science teachers (grades 1–12)
Influence of new science buildings on patterns of science education, and vice versa
Impact of science affairs on the teaching of science
Visiting scientists programs for high schools and colleges
Science research programs in high schools

SCHOOL SCIENCE AND MATHEMATICS has agreed to assist in this project by collecting and summarizing questions of interest to its readers. All readers are urged to send to the EDITOR immediately any questions that might be of use in the project. They should be addressed to EDITOR, SCHOOL SCIENCE AND MATHEMATICS, 535 Kendall, Kalamazoo, Michigan.

Problem Department

Conducted by Margaret F. Willerding

San Diego College, San Diego, Calif.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problem should be well done in India ink. Problems and solutions will be credited to their authors. Each solution or proposed problem sent the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The editor of the Department desires to serve her readers by making it interesting and helpful to them. Address suggestions and problems to Margaret F. Willerding, San Diego State College, San Diego, Calif.

SOLUTIONS AND PROBLEMS

Note. Persons sending in solutions and submitting problems for solution should observe the following instructions.

1. Solutions should be in typed form, double spaced.

2. Drawings in India ink should be on a separate page from the solution.

3. Give the solution to the problem which you propose if you have one and also the source and any known references to it.

4. In general when several solutions are correct, the one submitted in the best form will be used.

2779. *Proposed by H. C. Torreyson, Prospect Heights, Ill.*

A math student stopped at the book store and inquired the price of a certain book. He was told that the price of the book with the standard hard cover was \$1.60; with deluxe cover, \$2.00; and with paper back, \$.90.

"Which do most students buy?," he asked.

"We have sold the last 100 copies for \$100," he was told, "figure it out for yourself."

How many copies of each were included in the 100 copies?

Solution by Walter S. Hornsby, III, Atlanta, Ga.

Letting

x = number of copies of standard hard cover books,
y = number of copies of deluxe cover books, and
z = number of copies of paper back books,

two equations may be derived from this problem which are:

$$\$1.60x+\$2.00y+\$.90z=\$100.00 \tag{1}$$

$$x+y+z=100. \tag{2}$$

This system of equations may readily be reduced to

$$7x+11y=100. \tag{3}$$

After having reduced this problem down to one equation in two unknowns, I will proceed to solve this by means of congruences.

$$100\equiv 7x(\text{Mod } 11)$$

$$5\equiv 2x(\text{Mod } 11)$$

$$x\equiv 8\ (\text{Mod } 11).$$

Therefore x is of the form $11n+8$, substituting in (3) we have:

$$7(11n+8)+11y=100$$
$$y=4-7n.$$

Here we see that y is of the form $4-7n$.

Substituting these values for x and y in equation (1), which may be written,

$$16x+20y+9z=1000,$$

we have

$$16(11n+8)+20(4-7n)+9z=1000.$$

Solving this equation for z we obtain:

$$z=88-4n.$$

Upon examination of the following equations,

$$x=11n+8$$
$$y=4-7n$$
$$z=88-4n,$$

we find that for x, y, and z to be positive, $n=0$.

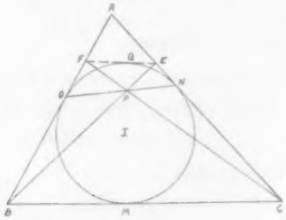
Thus the solution is;

8 copies of standard hard cover books,
4 copies of the deluxe cover books, and
88 copies of the paper back books.

Solutions were also offered by Brother Alfred, St. Mary's College, Calif.; Phillip Anderson, Muskegon Heights, Mich.; Merrill Barnebey, Grand Forks, N. D.; Donald R. Byrkit, West Chicago, Ill.; H. R. Leifer, Pittsburgh, Pa.; Michael McPherson, Milwaukee, Wis.; J. H. Means, Austin, Texas; Fred Miller, Elkins, W. Va.; Brother Norbert, Cleveland, Ohio; Gerald Robb, Livermore, Calif.; Fred J. Scharmann, Sheffield Lake, Ohio; Warren Rufus Smith, Brooklyn, N. Y.; Ben L. Swensen, Baytown, Texas; Wayne White, Camden, Ark.; and the proposer.

2780. *Proposed by D. Moody Bailey, Princeton, W. Va.*

The incircle of triangle ABC touches sides BC, CA, and AB at points M, N, and O respectively. P is any point on NO through which rays from B and C are drawn. BP meets CA at E and CP meets AB at F. Show that FE is tangent to the incircle of triangle ABC for all positions of point P on line NO.



Solution by the proposer

Allow a, b, and c to represent sides BC, CA, and AB of triangle ABC and let I be the center of the incircle. In the accompanying figure, for all positions of point P on NO, we have

$$\frac{AF}{FB}\cdot\frac{BO}{OA}+\frac{AE}{EC}\cdot\frac{CN}{NA}=1.$$

Proof of this statement may be found in the article entitled "A Triangle Theorem" occurring in the March, 1960 issue of SCHOOL SCIENCE AND MATHEMATICS. Now $BO=p-b$, $OA=p-a$, $CN=p-c$, and $NA=p-a$ where p is half the perimeter of triangle ABC. Also $FB=c-AF$ and $EC=b-AE$. The relationship

$$\frac{AF}{FB}\cdot\frac{BO}{OA}+\frac{AE}{EC}\cdot\frac{CN}{NA}=1$$

may then be rewritten as

$$\frac{AF}{c-AF}\left(\frac{p-b}{p-a}\right)+\frac{AE}{b-AE}\left(\frac{p-c}{p-a}\right)=1.$$

Substituting

$$\frac{a+b+c}{2}$$

for p and simplifying, this equation becomes

$$AE=\frac{b^2c+bc^2-abc-2bc\cdot AF}{2bc-AF(a+b+c)} \tag{1}$$

Suppose that FE is tangent to the incircle at a point Q. We would then have $FQ=OF$ and $QE=EN$ or $FQ+QE=OF+EN$ which becomes $FE=OF+EN$. Conversely, if $FE=OF+EN$, we shall know that FE is tangent to circle I. Can we show that $FE=OF+EN$?

Considering triangle AFE we have

$$\overline{FE}^2=\overline{AF}^2+\overline{AE}^2-2AF\cdot AE\cos A. \tag{2}$$

Also

$$OF=AO-AF=p-a-AF$$

and

$$EN=AN-AE=p-a-AE.$$

So

$$OF+EN=2(p-a)-(AF+AE)$$

and

$$(OF+EN)^2=[2(p-a)-(AF+AE)]^2. \tag{3}$$

We experiment by placing the right member of equation (2) equal to the right member of equation (3) and have

$$\overline{AF}^2+\overline{AE}^2-2AF\cdot AE\cos A=[2(p-a)-(AF+AE)]^2. \tag{4}$$

In(4) we substitute from (1) for AE, replace p by

$$\frac{a+b+c}{2},$$

and substitute

$$\frac{b^2+c^2-a^2}{2bc}$$

for cos A. This latter value comes from a consideration of triangle ABC where $a^2=b^2+c^2-2bc\cos A$. After a rather extended computation (4) finally reduces

to an identity. As the right members of (2) and (3) turn out to be equal, it follows that the left members of the two equations are also equal and we have $\overline{FE}^2=(OF+EN)^2$ or

$$FE=OF+EN. \tag{5}$$

Consequently, FE is tangent to incircle I as was to be proved.

If we allow P to traverse NO extended, we may make necessary changes in the value of AF and AE together with the expression of FE as the difference of segments OF and EN and thereby show that FE is still tangent to circle I. Therefore, as P traverses NO in its entirety, FE will envelop the incircle I of triangle ABC.

2781. *Proposed by Walter H. Carnahan, Madison, Wis.*

Find the smallest pair of consecutive even integers each of which is the sum of two cubes.

Solution by Sister Edith Louise, S.C., Mt. Clemens, Mich.

Taking the cubes of the numbers from 1 to 10 and determining the sum of all the pairs formed by these cubes, we find that

$$6^3+8^3=728 \quad \text{and} \quad 1^3+9^3=730$$

are the smallest consecutive even integers each of which can be expressed as the sum of two cubes.

Solutions were also submitted by Brother Alfred, St. Mary's College, Calif.; Donald R. Byrkit, West Chicago, Ill.; Robert S. Cunningham, Concord, N. H.; and H. C. Torreyson, Prospect Heights, Ill.

2782. *No complete solution has been offered.*

2783. *Taken from "More Problematical Recreations"*

At a party there are: 14 girls, 11 adults without costumes, 14 women, 10 girls with costumes, 24 people without costumes, 8 women with costumes and 10 males with costumes. How many people are at the party?

Solution by H. R. Leifer, Pittsburgh, Pa.

Since there are 10 males, 10 girls, and 8 women with costumes, there are 28 people with costumes, and since there are 24 people without costumes, there must be 52 people at the party.

Solutions were also submitted by Jane Bedrick, Linden, N. J.; Donald R. Byrkit, West Chicago, Ill.; Sister Edith Louise, Mt. Clemens, Mich.; Janet Means, Austin, Texas; Warren Rufus Smith, Brooklyn, N. Y.; and H. C. Torreyson, Prospect Heights, Ill.

2784. *Proposed by G. P. Speck, Virginia, Minn.*

In the August 1959 issue of the *Scientific American* the interesting irrational number ϕ is considered in connection with the additive Fibonacci sequence: 1, 1, 2, 3, 5, 8, 13, 21, 34, $\cdots$. It is stated that

$$\lim_{n\to\infty}\frac{A_{n+1}}{A_n}=\phi=\frac{1+\sqrt{5}}{2}\cdot$$

Prove this.

Solution by Donald R. Byrkit, West Chicago, Ill.

Let

$$\lim_{n\to\infty}\frac{A_{n+1}}{A_n}=x.$$

Since

$$A_{n+1}=A_n+A_{n-1}, \qquad x=\lim_{n\to\infty}\left(1+\frac{A_{n-1}}{A_n}\right).$$

But

$$\lim_{n\to\infty}\frac{A_n}{A_{n-1}}=x;$$

therefore

$$\lim_{n\to\infty}\frac{A_{n-1}}{A_n}=\frac{1}{x}\cdot$$

Hence

$$x=\lim_{n\to\infty}\frac{A_{n-1}}{A_n}=\lim_{n\to\infty}\left(1+\frac{A_{n-1}}{A_n}\right)=1+\lim_{n\to\infty}\frac{A_{n-1}}{A_n}=1+\frac{1}{x}\cdot$$

The equation $x=1+1/x$ has as its positive root

$$x=\frac{1+\sqrt{5}}{2}\cdot$$

Therefore

$$\lim_{n\to\infty}\frac{A_{n+1}}{A_n}=\frac{1+\sqrt{5}}{2}\cdot$$

Since no use was made of the fact that this was the Fibonacci sequence, this result holds for any additive sequence of this type.

Solutions were also submitted by George S. Cunningham, Concord, N. H.; and George Diderrich, Milwaukee, Wis.

STUDENT HONOR ROLL

The Editor will be very happy to make special mention of classes, clubs, or individual students who offer solutions to problems submitted in this department. Teachers are urged to report to the Editor such solutions.

Editor's Note: For a time each student contributor will receive a copy of the magazine in which his name appears.

The Student Honor Roll for this issue appears below.

2779. *Judy Arndt, Regina Dominican High School, Wilmette, Ill.*

2779. *Jean Husted and Norene Gill, Firelands High School, Oberlin, Ohio*

2779. *Bob Adams and Helen Rose, Robert E. Lee High School, Baytown, Texas.*

2779. *Janet Rodney, North Scranton Junior High School, Scranton, Pa.*

2783. *Jim Berger and Bobby Baglan, Carrollton, Ky.*

2784. *Nathan Cahn, Menlo-Atherton High School, Atherton, Calif.*

PROBLEMS FOR SOLUTION

2803. *Proposed by Brother Felix John, Philadelphia, Pa.*

The sum of two roots of the equation

$$x^4-8x^3+21x^2-20x+5=0 \text{ is } 4.$$

a) Explain why, on attempting to solve the equation from the knowledge of this fact, the method fails. b) Solve the equation.

2804. *Proposed by Fred A. Miller, Elkins, W. Va.*

A right circular cylinder of radius r is intersected by two planes, the first of which is perpendicular to the axis of the cylinder, and the second makes an angle θ with the first. Find the volume of the portion of the cylinder included between these two planes if their line of intersection is a diameter of the circle cut from the cylinder by the first plane. Use parallel sections perpendicular to the axis of the cylinder.

2805. *Proposed by Cecil B. Read, Wichita, Kans.*

Show that $(n!)^2$ exceeds n^n.

2806. *Proposed by William K. Viertal, Canton, N.Y.*

Use the duodecimal system to find a) $\sqrt{981e14}$ and b) $\sqrt{981t00}$, correct to two decimal places.

2807. *Proposed by J. W. Lindsey, Amarillo, Texas.*

If $8x = \ln 3$, prove that

$$\tan 15° = (e^{2x} - e^{-2x})/(e^{2x} + e^{-2x}).$$

2808. *Proposed by C. W. Trigg, Los Angeles City College.*

There are two integers with three like middle digits and such that each of their squares consists of a permutation of the digits from zero through eight. Find them and show that there are no others.

Books and Teaching Aids Received

BIOLOGY

UNRESTING CELLS, by R. W. Gerard. Paper $20\frac{1}{2} \times 13$ cm. 1961. 434 pages. Harper & Brothers, 49 East 33rd Street, New York 16, N. Y. Price $2.25.

THE SOCIAL INSECTS, by O. W. Richards, Paper. $20\frac{1}{2} \times 13$ cm. 1961. 217 pages. Harper & Brothers, 49 East 33rd Street, New York 16, N. Y. Price $1.50.

ANIMAL ECOLOGY, by W. H. Dowdeswell. Paper. $20\frac{1}{2} \times 13$ cm. 1961. 207 pages. Harper & Brothers, 49 East 33rd Street, New York 16, N. Y. Price $1.50.

MATHEMATICS, COLLEGE

CALCULUS, by George B. Thomas, Jr., *Massachusetts Institute of Technology.* Cloth. $23 \times 14\frac{1}{2}$ cm. 1961. 850 pages. Addison-Wesley Publishing Co., Inc., Reading, Massachusetts. Price $8.75.

FUNDAMENTALS OF COLLEGE MATHEMATICS, by John C. Brixey & Richard V. Andree, *University of Oklahoma.* $23\frac{1}{2} \times 15$ cm. Cloth. 1961. 750 pages. Holt, Rinehart & Winston, Inc., 283 Madison Ave., New York 17. N. Y. Price $8.95.

CALCULUS OF FINITE DIFFERENCES, by Charles Jordan. Cloth. 20×13 cm. 1961. Chelsea Publishing Co., 50 E. Fordham Rd., New York 68, N. Y. Price $6.00.

CALCULUS OF VARIATIONS, by Oskar Bolza, *Professor of Mathematics, University of Frieburg*. Paper. $20\frac{1}{2} \times 13\frac{1}{2}$ cm. 1961. Chelsea Publishing Co., 50 E. Fordham Rd., New York 68, N. Y.

MATHEMATICS, SECONDARY

INSERVICE EDUCATION OF HIGH SCHOOL MATHEMATICS TEACHERS, prepared by Kenneth E. Brown & Daniel W. Snader, *Specialists for Mathematics*. Paper. $23\frac{1}{2} \times 14\frac{1}{2}$ cm. 1961. 108 pages. U. S. Department of Health, Education, & Welfare, Office of Education, Washington D. C.

ALGEBRA, SECOND COURSE, by John R. Mayor, *American Assn. for Advancement of Science & The University of Maryland* & Marie S. Wilcox, *Head of Mathematics Department, Thomas Carr How High School, Indianapolis, Indiana*. Cloth. $23 \times 14\frac{1}{2}$ cm. 1961. 492 pages. Prentice-Hall, Inc. Englewood Cliffs, N. J. Price $4.36.

HIGH SCHOOL MATHEMATICS, prepared by University of Illinois Committee on School Mathematics University of Illinois Press, Urbana, Illinois. Paper. 28×21 cm. 1961.

INTRODUCTION TO MATHEMATICS, by Charles F. Brumfiel, *Ball State Teachers College*, Robert E. Eicholz, *Ball State Teachers College, Burris Laboratory School*, & Merrill E. Shanks, *Purdue University*. Cloth. $23 \times 14\frac{1}{2}$ cm. 1961. 318 pages. Addison-Wesley Publishing Co., Reading, Massachusetts. Price $4.00.

PYTHAGOREAN NUMBERS CONGRUENCES, A FINITE ARITHMETIC. GEOMETRY IN THE NUMBER PLANE, by Frederick H. Young, *Montana State University*. $23 \times 15\frac{1}{2}$ cm. Paper. 1961. Ginn and Co., Statler Building, Boston 17, Mass. Price $.80.

THE NATURE OF THE REGULAR POLYHEDRA INFINITY AND BEYOND. AN INTRODUCTION TO GROUPS, by Frederick H. Young, *Montana State University*. Paper. $23 \times 15\frac{1}{2}$ cm. 1961. Ginn and Co., Statler Building, Boston 17, Mass. Price $.80.

MATHEMATICS, MISC.

NEW THINKING IN SCHOOL MATHEMATICS, issued by OEEC. Paper. $14 \times 15\frac{1}{2}$ cm. 1961. 246 pages. OEEC, 1346 Connecticut Ave., N.W. Washington 6, D. C.

SCHOOL MATHEMATICS IN OEEC COUNTRIES, issued by OEEC. Paper. 24×15 cm. 116 pages. OEEC, 1346 Connecticut Ave., N..W, Washington 6, D. C.

INTRODUCTION TO MATRICES & VECTORS, by Jacob T. Schwartz, *Professor of Mathematics, Institute of Mathematical Sciences, N. Y. University*. Cloth. $23 \times 14\frac{1}{2}$ cm. 160 pages. McGraw-Hill Book Co., 330 West 42nd Street, N. Y. 36, N. Y. Price $5.50.

I CAN LEARN ABOUT CALCULATORS & COMPUTERS, by Raymond G. Kenyon. Cloth. $24\frac{1}{2} \times 18$ cm. 112 pages. 1961. Harper & Brothers, 49 East 33rd Street, New York 16, N. Y. Price $2.95.

A CONFERENCE ON MATHEMATICS CURRICULA IN INSTITUTES, sponsored & planned by the MAA Comm. on Institutes. Paper. $25\frac{1}{2} \times 17$ cm. 1961. National Science Foundation, Washington D. C.

MORE NUMBERS: FUN & FACTS, by J. Newton Friend. Cloth. $18\frac{1}{2} \times 11\frac{1}{2}$ cm. 1961. 199 pages. Charles Scribner's Sons, 597 Fifth Avenue, New York 17, N. Y. Price $2.95.

SCIENCE, ELEMENTARY

THE TRUE BOOK OF HORSES, by Elsa Posell. Cloth. 21×17 cm. 1961. 47 pages. True Books, Children's Press, Chicago 7, Illinois. Price $2.00.

THE TRUE BOOK OF WEATHER EXPERIMENTS, by Illa Podendorf. Cloth. 21×17 cm. 1961. 47 pages. True Books, Children's Press, Chicago 7, Illinois. Price $2.00.

THE TRUE BOOK OF DOGS, by Elsa Posell. Cloth. 21×17 cm. 1961. 47 pages. True Books, Children's Press, Chicago 7, Illinois. Price $2.00.

TERRARIUMS & AQUARIUMS, by Jerome Leavitt & John Huntsberger. Cloth. 21×17 cm. 1961. 47 pages. True Books, Children's Press, Chicago 7, Illinois. Price $2.50.

THE TRUE BOOK OF MAGNETS & ELECTRICITY, by Illa Podendorf. Cloth. 21×17 cm. 1961. 47 pages. True Books, Children's Press, Chicago 7, Illinois. Price $2.00.

RADIO BUILDING, by Joseph A. Smith. Cloth. 21×17 cm. 1961. 63 pages. True Books, Children's Press Chicago 7, Illinois. Price $2.50.

I WANT TO BE A SPACE PILOT, by Carla Greene. Cloth. 21×17 cm. 1961. True Books, Children's Press, Chicago 7, Illinois. Price $2.00.

I WANT TO BE A SCIENTIST, by Carla Greene. 24×19½ cm. 1961. True Books, Children's Press, Chicago 7, Illinois. Price $2.00.

FILMSTRIP: C 6438 SERIES: JUNIOR SCIENCE. TITLE: OUR WEATHER. Educational Productions Limted, East Ardsley, Wakefield, Wakefield, Yorks. Price $5.00.

HOW LIFE GOES ON, by Irving Zeichner. Cloth. 21×13½ cm. 1961. Prentice-Hall, Inc. Englewood Cliffs, N. J. Price $2.95.

MATTER, ENERGY & CHANGE, Explorations in Chemistry for Elementary School Children. Paper. 28×21 cm. Prepared by Mr. Harry Milgrom, *Supervisor of Science, New York City Elementary Schools*. Holt, Rinehart & Winston, Inc. In Cooperation with the Manufacturing Chemists' Assn., Inc.

SCIENCE, MISC.

IMPACT OF THE SPACE AGE ON INDUSTRIAL AND EDUCATIONAL COMMUNITIES, prepared by Ralph E. Meyer, *Technical Assistant to the Director, POLARIS Program* with contributions by: W. R. Kirchner, J. B. Cowen, I. L. Herman, A. D. Watt. Paper. 28×20½ cm. 1961. 9 pages. Aerojet-General Corp. Sacramento, California.

SPACE & TIME, by Emile Borel. Paper. 20½×13 cm. 1961. 234 pages. Dover Publications, Inc. 180 Varick Street, New York 14, N. Y.

THE STORY OF ATOMIC THEORY AND ATOMIC ENERGY, by J. G. Feinberg. 20½×13 cm. 1961. 263 pages. Dover Publications, Inc., 180 Varick Street, New York 14, N. Y. Price $1.45.

PIONEERS OF SCIENCE, by Sir Oliver Lodge, *Late Principal of Birmingham University*. Paper 20½×12½ cm. 1961. 404 pages. Dover Publications, Inc., 180 Varick Street, New York 14, N. Y. Price $1.50.

SCIENCE AWAKENING, by B. L. Van Der Waerden. 25×17½ cm. 1961. 306 pages. Oxford University Press, 417 Fifth Ave., New York 16, N. Y. Price $7.50.

SCIENCE TEACHING TECHNIQUES—VII. Paper. 21½×13½ cm. 1961. 64 pages. John Murray, Publisher, Albemarle Street, London, W.1.

GEOLOGY & RELATED SCIENCE SOURCEBOOK for Elementary & Secondary School Science Courses. Paper. 28×21½ cm. 1961. Prepared under the Guidance of the American Geological Institute Washington 25, D. C.

TELEVISION FOR SCHOOL SCIENCE. Report on an OEEC Seminar, Ashridge (England), July, 1960. Paper. 24×15 cm. 1961. OEEC, 1346 Connecticut Ave., N.W., Washington 6, D. C.

MISCELLANEOUS

THE ADOLESCENT SOCIETY, by James S. Coleman, *Johns Hopkins University.* Cloth. 23½×15 cm. 1961. The Free Press of Glencoe, 640 Fifth Ave., New York 19, N. Y. 368 pages.

ENGINEERING ENROLLMENTS AND DEGREES 1960, by Wayne E. Tolliver, *Education Research and Program Specialist, Education Statistics Branch* and Henry H. Armsby, *Chief of Engineering Education, Division of Higher Education.* Paper. 26×20 cm. 1961. U. S. Department of Health, Education, and Welfare, U. S. Government Printing Office, Washington 25, D. C. Price $.35. 44 pages.

YOUTH PHYSICAL FITNESS—SUGGESTED ELEMENTS OF A SCHOOL-CENTERED PROGRAM, President's Council on Youth Fitness. Paper. 23½×14½ cm. 1961. National Education Assn. of U. S. Washington 25, D. C. 14 pages.

FUNDAMENTALS OF PHYSICAL GEOGRAPHY, by Glenn T. Trewartha, *Professor of Geography, University of Wisconsin*, Arthur H. Robinson, *Professor of Geography, University of Wisconsin*, & Edwin H. Hammond, *Associate Professor of Geography, University of Wisconsin.* Cloth. 23½×17 cm. McGraw-Hill Book Company, Inc., 330 W. 42nd Street, New York 36, N. Y. Price $6.95. 409 pp.

EDUCATORS GUIDE TO FREE FILMSTRIPS, Compiled & Edited by Mary Foley Horkheimer & John W. Diffor M. A., *Visual Education Director, Randolph High School, Randolph, Wisconsin.* Paper. 27½×21½ cm. 1961. 165 pages. Educators Progress Service, Randolph, Wisconsin. Price $6.00.

YOUTH PHYSICAL FITNESS—SUGGESTED ELEMENTS OF A SCHOOL-CENTERED PROGRAM, President's Council on Youth Fitness. Paper. 23½×14½ cm. 1961. National Education Assn. of U. S., Washington 25, D. C. 111 pages.

UNITED STATES GOVERNMENT GRANTS-EUROPE, NEAR EAST, FAR EAST, AFRICA, 1961. 98 pages. 21½×13½ cm. Conference Board of Associated Research Councils, Committee on International Exchange of Persons, 2101 Constitution Ave., Washington 25, D. C.

TEACHERS OF CRIPPLED CHILDREN AND TEACHERS OF CHILDREN WITH SPECIAL HEALTH PROBLEMS, Prepared by Romaine P. Mackie, *Chief Exceptional Children and Youth, U. S. Office of Education* and Frances P. Connor, Professor, *Special Education, Teachers College, Columbia University, New York.* Paper. 23×15 cm. 1961. United States Government Printing Office, Department of Education, Washington 25, D. C. Price $.50.

EDUCATION OF THE ADULT MIGRANT, by Edward Warner Brice, *Specialist in Fundamental and Literacy Education* Paper. 23×15 cm. 1961. United States Government Printing Office Department of Education, Washington 25, D. C. Price $.50.

REQUIREMENTS FOR HIGH SCHOOL GRADUATION, by Grace S. Wright, *Specialist for Secondary Education.* Paper. 23×15 cm. 1961. 29 pages. United States Government Printing Office, Department Of Health, Education, and Welfare Washington 25, D. C.

EDUCATOR'S GUIDE—FREE FILMS, Paper. $27\frac{1}{2}\times21$ cm. 1961. 636 pages A. P. Horkheimer, Publisher, Educators Progress Service, Randolph, Wisconsin. Price $9.00.

TEACHER SUPPLY AND DEMAND IN UNIVERSITIES, COLLEGES, AND JUNIOR COLLEGES, 1959–60 AND 1960–61. Paper. $28\times21\frac{1}{2}$ cm. 1961. 88 pages. Publications Editor, Research Division, N.E.A., 1201 Sixteenth St, N.W., Washington 6, D. C.

RECHT CHEM-FORMULATOR, Copyright 1960, Christian F. Recht, Boulder, Colorado. Order from P. O. Box 225, Boulder, Colorado.

STAR-BRYTE ATOM WHEEL Copyright 1960, Order from L. G. Williams (Star-Bryte), Route 2, Box 297 A, Martinez, Calif. Game Complete. $6.50 each ($4.50 each in quantities of 6 or more.

MICRO-SLIDE-VIEWER & SLIDES, National Teaching Aids, Inc., 386 Park Ave. So., New York 16, N. Y. Cost of a Basic School Package: With purchase of any 4 boxes 30 Micro-Slide-Viewers $106.

SET OF FILMSTRIPS: "Conserving Our Natural Resources." Encyclopaedia Britannica Films, Inc. 1150 Wilmette Ave., Wilmette, Ill.

1. "Enough Water for Everyone"
2. "What is Conservation?"
3. "Giving our Wildlife a Chance"
4. "Using Our Minerals Wisely"
5. "Improving Our Grasslands"
6. "Using Our Forests Wisely"
7. "Saving Our Soil"

COOPERATIVE-RESEARCH, by Richard F. Carter and William G. Savard, *Stanford University*. Paper, 23×14 cm. 31 pages. 1961. U. S. Department of Health, Education and Welfare, Office of Education, U. S. Government Printing Office, Washington 25, D. C. Price $.20.

COOPERATION FOR PROGRESS IN LATIN AMERICA, by Research and Policy Comm. of the Committee for Economic Development. Paper. 28×18 cm. 56 pages. 1961. Political and Economic Planning, 16 Queen Anne's Gate, London S.W. 1, England. Price $1.00.

NEW LIVES FOR OLD, by Margaret Mead. Paper. 18×10 cm. 1961. 464 pages. New American Library, of World Literature, Inc., 501 Madison Ave., New York 22, N. Y. Price $.75.

ON THE NATURE OF MAN, by John Langdon-Davies. Paper. 10×16 cm. 224 pages. 1961. The New American Library of World Literature, Inc., 501 Madison Avenue, New York 22, N. Y. Price $.50.

CURRENT PROJECTS ON ECONOMIC AND SOCIAL IMPLICATIONS OF SCIENTIFIC RESEARCH AND DEVELOPMENT 1960. Paper. 13.5×23 cm. 124 pages. Prepared by the National Science Foundation. Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. Price $.40 a copy.

RURAL RENAISSANCE—REVITALIZING SMALL HIGH SCHOOLS, by Edmund A. Ford, *Specialist for Secondary School Organization and Administration*. Paper. 14×19 cm. 54 pages. U. S. Department of Health, Education, and Welfare, Office of Education, Washington, D. C.

A HISTORY OF SCIENCE, TECHNOLOGY, AND PHILOSOPHY IN THE 18TH CENTURY, by A. Wolf. Both paper. Both 12.5×20.5 cm. 1961. Harper & Brothers, 49 East 33rd Street, New York 16, N. Y. Pages I through 409.
Volume I. Price $2.50.
Volume II—Pages 410 through 814. Price $2.50.

Book Reviews

SCIENCE TEACHING IN THE SECONDARY SCHOOL, by Nathan A. Washton, Science Education, Queens College, Flushing, N. Y. xx+328 pages. 14×21 cm. Harper & Brothers, 49 East 33d Street, New York City. Price, $5.00.

A practical, helpful book.

The author's basic philosophy—science teachers in secondary schools should not be narrow specialists, but well grounded in the humanities and social sciences as well as in the physical sciences.

Before preparing his manuscript. Prof. Washton wrote to a wide list of the nation's science educators (one criterion, membership in national science teachers' organizations), and culled the 150 replies received. "Most of these offered consistent suggestions," he reports in his preface; this, however, in no way detracts from his personal responsibility as author.

What has the book to offer? The first two chapters give "a reason for the hope that is in you" (I, Peter, 3: 15) as a science teacher. The third and fourth chapters offer broad outlines of well-organized science curriculum.

The fifth chapter concerns the biology teacher's "special problems" as to how biological topics may be related to the objectives of general education; how to handle heredity, eugenics, sex, . . . ; how to make the best use of a liberal equipment budget, also a scanty one. Wisely the author makes no suggestions as to presentation of the works of Darwin and the principle of evolution. Oliver Wendell Holmes wrote: "Truth is a good dog, but it should be careful of barking too close to the heels of error, lest it get its brains kicked out!"

The sixth chapter explains why the influence of the physical sciences should go far beyond the facts. One example—while physics and chemistry are the bases of atomic energy, the dangers are biological. And should not high school students consider the moral aspects of the use of this energy for war or for peace? Their generation must settle this problem to survive!

Chapters seven, eight and nine offer quite practical teaching aids and lists. These include the needs of audio-visual activities. Printed materials are classified, and their proper functions recommended. A number of techniques of instruction are described with clarity.

Chapter ten concerns evaluation—the question, evaluation for what? Certainly not merely to measure retention of scientific facts for a few months! Recent tests that seem to explore more worthwhile learnings are described. The teacher is also advised as to how to construct his own classroom tests, and feel that they are good.

Chapter eleven describes multipurpose science classrooms for more than a single grade level or a single science. The floor plans for four "total experience science laboratories" are published; they seem quite practical.

Chapter twelve is titled "Professional Growth of the Science Teacher"—intended as a climax, we are sure. Shall any science teacher become the butt of that sarcastic tale, "not twenty years' experience, but one year's experience, repeated nineteen times"? Not if he considers himself a professional, and acts like one!

HANOR A. WEBB, Emeritus
GeorgePeabody College for Teachers, Nashville, Tenn.

ELEMENTARY MODERN PHYSICS, by Richard T. Weidner and Robert L. Sells. Cloth, 513 pages. 15×23 cm. 1960. Allyn and Bacon, Inc., 150 Tremont St., Boston 11, Mass. Price $8.50.

This textbook is written primarily for use in courses for engineering and science students. This course could follow the course in general physics, since the only pre-requisites assumed are elementary physics and introductory calculus.

The topics treated include classical physics, theory of special relativity, par-

ticle aspects of electromagnetic radiation, wave aspects of material particles, structure of the hydrogen atom, structure of many electron atoms, x-ray spectra, radiation detection, instruments and accelerating machines, nuclear structure, nuclear reactions, and solid-state physics.

The treatment of the topics appears to be excellent for the purpose intended. The authors have attempted to avoid a superficial descriptive text and also avoid a strictly mathematical treatment for which most students at the sophmore and junior levels in college are not prepared.

Summaries, references, and many well chosen problems are presented at the end of chapters. Answers to the odd numbered problems are given in the appendix. The textbook contains excellent illustrations and diagrams.

It is the opinion of the reviewer that the authors have succeeded in producing a textbook that is excellent for use at the sophmore or junior level in college.

J. Bryce Lockwood
Highland Park Junior College
Highland Park, Michigan

Heath Educational Kits, produced by Heath Company, a subsidiary of Daystrom Inc., Benton Harbor, Michigan.

The Heath Company has recently produced three educational kits designed for individual home study or classroom work. In all of these kits experimentation and testing are employed to teach the fundamentals of electricity and electrons as well as to produce a useful instrument.

Education Kit EK−2A ($19.95).

The textbook included in this kit is written to teach the fundamentals of radio transmission, detector circuits, tuned circuits, the diode vacuum tube detector, the triode vacuum amplifier, and the use of feedback for amplification. In the first part of this kit a crystal receiver is constructed. Parts are then added in succession to improve on the basic circuit. Upon completion the student has assembled a regenerative tube-type receiver.

Educational Kit EK–2B ($19.95).

This kit is designed to teach the fundamentals of the receiver power supply, the receiver audio section, the receiver RF section, the oscillator, the converter circuit, alignment and short wave. This is a continuation of EK–2A and that kit is necessary in the assembly of EK−2B. The completion of this kit results in a 6-tube 2-band superheterodyne receiver.

The reviewer asked two students to assemble these kits under supervision. These students stated that they believed the kits were excellent educational devices.

Educational Kit EK–1 ($19.95).

The first in the series consists of a text—workbook and parts for assembly of a DC volt—ohm—millimeter. The textbook is written to teach fundamentals of DC electricity including atomic structure series and parallel circuits, Ohm's Law, maximum power transfer theorem, construction of ammeters, voltmeters, and ohmmeters, and testing of electrical applicances. The test instrument assembled is essential in the construction of the more advanced kits if maximum educational value is desired.

It is the opinion of this reviewer that the coordination of pictorial and schematic diagrams of various circuits was presented in an excellent manner. As a result, a student with little electronics background can began many of the basic principles that will enable him to read, comprehend, and construct simple electronic circuits. The principles of transmission and reception were presented in such a manner that an average student would have little difficulty in understanding them. The course would require some supervision by an instructor to assist the students in some steps.

J. Bryce Lockwood

SUMMER FELLOWSHIPS FOR SECONDARY SCHOOL TEACHERS

As one means of improving the teaching of science and mathematics in American secondary schools, the National Science Foundation plans to award on March 15, 1962, several hundred Summer Fellowships for Secondary School Teachers of Science and Mathematics. These fellowships will be awarded to support individually planned programs of study in the mathematical, physical, and biological sciences at a level that is acceptable by the fellowship institution toward an advanced degree in any of these subject matter disciplines. It is not necessary that the Fellow be pursuing a course of study leading to an advanced degree in science; it is necessary only that his studies be at that level. Only individuals with the background and ability requisite for graduate-level work in the subject matter areas of science and mathematics should apply for these fellowships.

Eligibility

An application for a National Science Foundation Summer Fellowship for Secondary School Teachers may be submitted by any individual who (a) is a citizen or national of the United States as of March 1, 1962, (b) now teaches in a secondary school in the United States, its Territories or possessions, or in a secondary school conducted elsewhere for the benefit of United States citizens, (c) will have had by July 1, 1962 not less than 3 years' experience as a full-time secondary school teacher, (d) normally teaches during each school year at least one class in either science or mathematics in a secondary school, (e) holds a baccalaureate degree or its equivalent, and (f) intends to continue teaching.

Stipends and Allowances

Stipends will be computed at the rate of $75 per week for each week of tenure. Fellows will normally be provided an allowance of an additional $15 per week for each dependent. A travel allowance will be computed at the rate of eight cents per mile but may not exceed $80 in any one summer. Tuition and certain fees assessed and collected from individuals whose academic standing is similar to that of the Fellow will be paid by the Foundation to each Fellow's institution.

Tenure

Tenures of one, two or three summers—each consisting of from six to twelve weeks—will be available.

Applications

Application materials may be obtained by addressing a request to: Secondary School Fellowships, American Association for the Advancement of Science, 1515 Massachusetts Avenue, N. W., Washington 5, D. C. Completed materials must be received by the Association not later than January 5, 1962. Fellowships will be awarded on March 15, 1962.

WASTE LIGNIN USED TO MAKE AUTO TIRES

By use of lignin, a waste product in paper manufacture comprising a large percentage of wood, satisfactory tires can be made with a reduction of the crude rubber content of 10% to 40%.

This chemical result was announced to the Chemical Institute of Canada by a team of Canadian chemists from the National Research Council, Ottawa, the Howard Smith Paper Mills, Cornwall, Ont., and the Army Development Establishment, Ottawa.

Lignin is used in both the carcass and tread of the tires that are large of diameter and of nylon cord construction.

SEMINAR ON THE STATUS AND DEVELOPMENT OF THE TEACHING OF CHEMISTRY—GREYSTONES, IRELAND

This seminar, held under the auspices of the Office for Scientific and Technical Personnel of the Organization for European Economic Cooperation (OEEC), was attended by delegates from Austria, Belgium, Denmark, France, Germany, Greece, Iceland, Ireland, Italy, Luxemburg, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, the United Kingdom, and the United States. U. S. representatives were: J. A. Campbell, Harvey Mudd College, Claremont, California; L. E. Strong, Earlham College, Richmond, Indiana; Robert Rice, University of California, Berkeley, California; and Paul Westmeyer, University of Illinois, Urbana, Illinois.

The following recommendations were made by the seminar to the OEEC.

1. Within an appropriate time three ad hoc committees should be set up on an international basis, each committee to consist of six to eight members and comprising university teachers, secondary school teachers and school inspectors from the various Member Countries. The duties of these committees should be:

   Committee A

   To examine the developments in theoretical chemistry in their application to secondary school teaching and in the light of the reports from the Seminar and the comments received thereon from the Member Countries. To draft the outline of a modern syllabus of chemistry suitable for adaptation in the secondary schools of Member Countries. That this syllabus be expanded by explanatory notes and published by the OEEC as a manual or handbook to serve as a guide to teachers of chemistry in secondary schools.

   Committee B

   To undertake a similar task in relation to practical chemistry and extend the above manual to contain laboratory and demonstrational experiments suitable to illustrate the modern course in chemistry envisaged and suitable also to the demands of the outstanding advances in practical chemical techniques.

   Committee C

   To examine the position relating to the training and retraining of teachers of chemistry in secondary schools with a view to establishing by means of recommendations per OEEC to Member Countries and by other means the machinery necessary to ensure an adequate supply of teachers who are fully conversant with modern scientific developments and capable of teaching a course in chemistry in secondary schools based on modern ideas and concepts.

2. The Seminar stressed the necessity for physics and mathematics being taught to chemistry students so that these students will have at all stages of instruction the necessary background in physics and mathematics to appreciate the development of their chemistry. In this connection it was considered desirable that physics—particularly introductory electricity, mathematics and elementary notions of solid geometry, should precede the introduction of chemistry. While it was conceded that physics and chemistry being taught by the same person would be a desirable arrangement in junior courses in these subjects, it was emphasized that for proper development of these separate disciplines, specialist teachers of each subject were required at the more advanced stages of secondary school teaching. It was generally agreed that much coordination of the subjects mathematics, physics and chemistry could be achieved by cooperation of teachers in the planning and timing of courses.

3. The Seminar considers that the following topics should form the basis of an approach to the teaching of chemistry at all levels and be emphasized particularly at the higher levels of chemistry teaching in secondary schools.
   a. Atomic structure and electronic theory of valency;
   b. Chemical equilibria;
   c. Energy considerations in chemical reactions;
   d. The elimination, particularly from inorganic chemistry, of disconnected factual matter unnecessary for illustrating underlying principles and for coordinating the subject into a logical unit. The development of "horizontal" and "vertical" knowledge of the facts of inorganic chemistry was held to be of primary importance.
4. It is the opinion of the Seminar that practical work, both demonstration to illustrate lessons on theory and actual experimental work performed by students in the laboratory, is indispensable to the proper teaching of chemistry at all stages in the secondary school program.
5. The Seminar suggests that the OEEC recommend to Member Countries who operate a national syllabus and examination, that designated schools be permitted to teach other approved courses on an experimental basis and that arrangements be made for the examination of such courses.
6. In view of the importance of teacher retraining programs to provide personnel to put into operation the modernized course in chemistry, the Seminar requests the OEEC to discuss with the suitable authorities in the various Member Countries the promotion and financing of extensive schemes of retraining teachers of chemistry.

A final report of the Seminar is scheduled for publication in late spring 1961. An appropriate announcement will be made when this publication becomes available.

CENTRAL ASSOCIATION OF SCIENCE AND MATHEMATICS TEACHERS, INC.

APPLICATION FOR MEMBERSHIP

Date .... 19......

I hereby apply for membership in the Central Association of Science and Mathematics Teachers, Inc., and enclose $5.00 for annual membership dues, which includes one year's subscription to SCHOOL SCIENCE AND MATHEMATICS. I will receive nine issues of this journal, none being published in July, August or September. (Subscriptions beginning with January issue expire with December; with October issue expire with June.)

Begin: JANUARY ☐ Begin: OCTOBER ☐
(PLEASE PRINT)

Name ....
Last Name First Name

School Address ....
Name of School City State

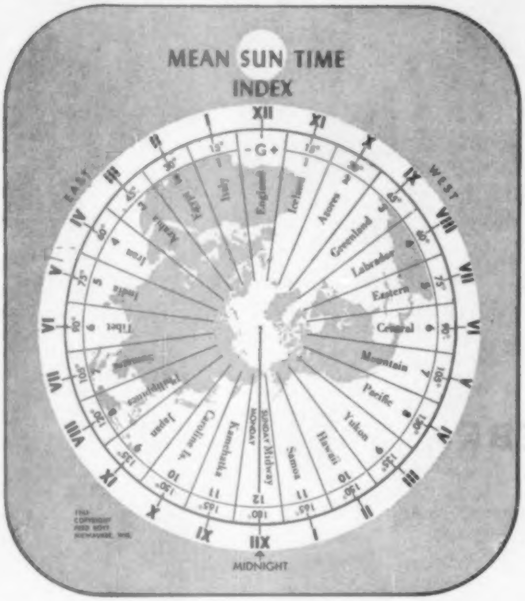
Home Address ....
Street City Postal Zone State

Journals will be sent to home address unless otherwise requested

Underline Section in which enrollment is desired: *Biology, Chemistry, Elementary Science, Elementary Mathematics, General Science, Geography, Mathematics, Physics* ....

Mail this application with $5.00 (Canada $5.00, Foreign $5.50) to Central Association of Science and Mathematics Teachers, Inc., P.O. Box 108, Bluffton, Ohio.

PLEASE CHECK IF YOU FORMERLY WERE A MEMBER ☐


MEAN SUN TIME
INDEX
EAST
WEST
MIDNIGHT


CLOCK FAST
CLOCK SLOW